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AGRICULTURE AND TRADE AMONGST THE GARAMANTES AND THE FEZZANESE: 3000 YEARS OF ARCHAEOBOTANICAL DATA FROM THE SAHARA AND ITS MARGINS

by

Ruth Elizabeth Pelling

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"Whoever makes two blades of grass or two ears of corn grow where only one grew before serves mankind better than the whole race of politicians."

(Jonathan Swift, 1724)

Abstract

The nature and effectiveness of subsistence strategies are central to many theories concerning emergent complex societies and urban centres. A thorough understanding of subsistence can only be achieved by including the study of the actual plant and faunal remains which formed the subsistence base. Although research over the last two decades has slowly redressed the situation, archaeobotanical studies have hitherto been very limited within Africa, particularly outside the Nile Valley. Existing studies have tended to be dominated by testing theories concerning African centres of domestication and the origins of agriculture, in particular the origins of cultivated *Pennisetum* (pearl millet) or *Sorghum*. In terms of 'complex societies' and their development, assumptions concerning the subsistence base have tended to be made in the absence of detailed archaeobotanical sampling, although a growing number of excavations at 'urban' sites have recently included detailed sampling.

The focus of this thesis is the archaeobotanical evidence for agricultural activity and the role of agriculture within society during 2500-3000 years of Garamantian and post-Garamantian civilization in the Fazzān, Libyan Sahara. Settlement in the region, particularly at the proto-urban site of Old Jarma (the ancient Garamantian capital of Garama), shows a remarkable degree of longevity. This must in part reflect a successful agricultural adaptation to a marginal environment despite progressive aridification and demographic fluctuations. The current study sets out to demonstrate how this adaptive strategy included both technical and arable developments, but also exploited the economic opportunities afforded by a changing political climate on the fringes of the Sahara. To set the case study in its wider geographical context, a detailed database has been compiled of archaeobotanical data from sites across northern Africa including some newly generated, as yet unpublished data. Statistical methods are used to explore temporal and special relationships between the sites included in the database.

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Chapter 1
AGRICULTURAL ADAPTATION IN THE SAHARAN DESERT

1.1 Introduction

The nature and effectiveness of subsistence strategies are central to many theories concerning emergent complex societies and urban centres. A thorough understanding of subsistence can only be achieved by including the study of the actual plant and faunal remains which formed the subsistence base. Although research orientated work over the last decade has slowly redressed the situation, archaeobotanical studies have hitherto been very limited within Africa, particularly outside the area of the Nile Valley. Existing studies have tended to be dominated by testing theories concerning African centres of domestication. Concentrated archaeobotanical research, for example within the West African Sahel and Lake Chad region, has been largely concerned with the origins of farming and of cultivated *Pennisetum* (millet) (D'Andrea *et al.* 2001; Neumann, 1999; Breunig and Neumann 2002; Klee *et al.*. 2000).

Within the Sahara itself research has tended to focus on the prehistoric phases. Extensive studies have been conducted amongst the prehistoric rock shelters of pastoral groups in the Tadrat Akakus mountain range in the southern Fazzān (Mercuri 2001; Castelletti *et al.* 1998; Castelletti *et al.* 1999; Wasykikowa, 1993), which demonstrate the early-mid Holocene use of wild grasses. Similar evidence has been found from sites in the Egyptian Western Desert (Nabta Playa: Wasylikowa and Dahlberg 1999; Dakhleh Oasis: Thanheiser 1999; Farafra: Barakat and Fahmy 1999; Abu Ballas: Barakat and Fahmy 1999).

In terms of 'complex societies' and their origins and development, assumptions concerning the subsistence base, central to any such discussion, have tended to be made in the absence of detailed archaeobotanical sampling. A growing number of excavations at 'urban' sites on the fringes of the Sahara have now included more detailed sampling however, such as at Jenné-Jeno (McIntosh 1995) and more recently Dia (Murray 2004) in Mali. Similarly, detailed sampling of sites in Romanised North Africa in Tripolitania, Libya (Van der Veen, Grant and Barker 1996) has enabled qualitative statements to be made concerning the relationship between North African peoples and the Roman Empire.

The current study is one of the few from the central Sahara to focus on the historical period and the only example to provide a continuous record of archaeobotanical data throughout the agricultural period. As such these data provide a central Saharan record as significant as those from Qasr Ibrim in the Nubian Nile Valley (Rowley-Conwy 1989; Clapham and Rowley-Conwy, *forth.*). Beyond plotting occurrences and diffusion of crops, these data are demonstrating that the Sahara was not an impenetrable barrier prior to the introduction of the camel. The central Sahara may in fact have witnessed far more extensive movement of people and transfer of ideas, including crops and arable techniques, but also possible food types, technology, and cultural traditions, than had previously been thought.

1.2 Research Aims and Objectives

This current study focuses on the archaeobotanical evidence for agricultural activity and the role of agriculture within society during 2500-3000 years of Garamantian and post-Garamantian civilization in the Fazzān, Libyan Sahara. Archaeobotanical remains from the Fazzān and the wider Saharan region form the basis of the study while evidence is also drawn from the archaeological and artefactual data in order to explore aspects of crop processing, food preparation and consumption and cultural identity. Settlement in the region, particularly within the 'urban' site of Jarma (the ancient Garamantian capital of Garama) shows a remarkable degree of longevity. This presumably reflects a successful agricultural adaptation to the marginal environment despite progressive aridification and demographic fluctuations. During the study period the region was touched by, or had some contact with, a range of political, ethnic and religious influences. This project forms one of the few detailed studies of established agriculture within the Sahara itself. It is intended to form a case study for past oasis agriculture and adaptive strategies to farming within a marginal dry environment, based on the archaeobotanical remains themselves. In addition the study area is one which potentially bridges the gap, both geographically and archaeologically, between northern, Mediterranean and southern, sub-Saharan Africa, and it offers the opportunity to explore the role that the Garamantes and later populations played in the diffusion of arable crops and farming methodology through the Sahara.

The research aims of the project are:

- To conduct an archaeobotanical analysis of material recovered from the site of Jarma which will be complemented by archaeobotanical datasets from other sites in the Northern Fazzān.
- To produce a macro-regional database of archaeobotany from across northern Africa with which to explore the timing and nature of the diffusion of crops across the region.
- To use artefactual and feature evidence relating to food processing and consumption from Jarma and the region in order to explore cultural trends through time.
- Ethnographical evidence from the wider region will be discussed as a means of developing possible analogies for interpreting the archaeological data and building hypotheses for further investigation.

This chapter provides an introduction to the study area followed by a discussion of some relevant key issue in dry land agriculture and African theoretical archaeology. Some more detailed discussion of the specific aims of the current study is then given.

1.3 The Fazzān: the Climatic Background and the Emergence of Agriculture

The climatic history of the Sahara (fig 1.1) is now known to have been characterised by moist conditions punctuated by arid episodes and with an overall tendency towards current arid conditions (Gasse 2000; Hassan 1996; 1997; 2002). It is within this sequence that human settlement can be seen to expand and contract with rise and falls in water levels and the shift towards domestication of animals and plants occurred. Particularly severe arid periods have been recorded in the Fazzān from roughly 8000-7500 years bp (Cremaschi 1998; Cremaschi and di Lernia 1998; di Lernia 1999) and 6410-6082 uncalibrated years bp (di Lernia 2002), characterised by strong seasonal fluctuations and by the emergence of the *Acacia-Tamarix* association in the pollen record. The first arid phase is associated with a global event around 8200Cal BP (Alley *et al.* 1997) and in North Africa with the adoption of cattle herding and spread of food production (di Lernia 1999; 2002; Hassan 2002). The second major arid phase is linked to the "Bougdouma-Oyo" event (Hassan 2002, 1997; 1996) recorded across central-northern Africa (di Lernia and Palombini 2002). Dry events are recorded at a similar time in the Algerian Sahara (Alimen 1987), Chad (Maley 1981), Niger (Maley 1981) and Mali (Petit-Marie *et al.* 1983) with a brief dry interval recorded at c. 6000 bp at Oyo and Wadi Shaw, and at Bougdouma (Gasse and van Campo 1994; Vernet 1994; Hassan 1997). A final severe arid phase is recorded in the Fazzān at 5000-4800 years bp leading to current climatic conditions (Cremaschi 1998), also recorded across the Sahara and the Nile Valley between 5000 and 4500 bp (Hassan 2002; 1997; 1996; Kuper and Kröpelin 2006).

Progressive environmental degradation and 'regression of freshwater' continued across the Sahara between the 7th and 4th millennia BP with most of the lakes drying up at this time. Fluvial systems draining the highlands of south-west Fazzān were still active at 3800 BP which presumably aided continued late Pastoral activity in the area (Cremaschi 2001), while the plains were abandoned. In the Wādī al-Ajāl Uranium/Thorium (U/Th) and ^{226}Ra dating suggests that surface water at the base of the southern escarpment was either very scarce or non-existent by 3,100 ±125 BP (Drake *et al.* 2004).

Pollen records from the rock shelters in the Akakus show an increase in desert trees and herbaceous plants indicative of dry steppe and a reduction or disappearance in Savannah plants as dry conditions continued (Mercuri *et al.* 1998; Trevisan Grandi *et al.*, 1992; 1998). By the 4th millennium BP the settlement pattern indicates an abandonment of the rock shelters in favour of the oases or the edges of the mountains. An ephemeral presence of herders is suggested across the plains with a behavioural pattern that has been likened to the present Tuareg (Smith 1980; Cremaschi and Di Lerna 1998). This Late Pastoral Phase represents a period of accelerated social change in the Fazzān including the possible emergence of an elite, with an increasingly elaborate burial culture (Di Lerna *et al.* 2001), and a change in rock art to include more images of fertility. By the third millennium BP permanent settlement and irrigation based agriculture is attested in the

Fazzān (Van der Veen 1992) with an increased centralisation of settlement and the emergence of the Garamantes.

While the last 3000 years during which the study is concerned have been characterised by arid conditions, climatic fluctuations continued during the first millennia BC and AD with a final wet phase in the second half of the first millennium AD. A progressive drop in the water-table has reduced available ground water and resulted in the need to dig increasingly deep wells or shafts to reach fresh water for irrigation. The introduction of diesel fuelled artesian wells in the second part of the twentieth century has resulted in an acceleration of the drop in water table and desiccation of some of the remaining lakes. Modern climatic conditions in the Fazzān are hyper-arid with negligible rainfall. At the highest elevations rainfall averages 5-12mm per year, while in the valley floors rainfall is typically below 9mm, although with up to 300% variation (Allan *et al.* 1973). Temperatures in summer can reach 50°C while winter months are typically warm and dry in the day time with occasional frosts at night. Hot winds and dust storms are common particularly in spring.

Archaeobotanical evidence for increased and systematic exploitation and harvesting of wild grasses is available from sites within the Akakus Mountains which echoes that of the Eastern Saharan sites in the early and mid-Holocene (fig 1.1). The grass species consistently identified from early-Holocene Uan Afuda, Ti-n-Thora/Two Caves and Uan Muhuggiag and from mid-Holocene Uan Muhuggiag were dominated by *Brachiaria* and *Urochloa*, with additional seeds of *Cenchrus* sp., *Setaria* sp., *Panicum* sp., *Echinochloa* sp. and *Digitaria* sp. (Castelletti *et al.* 1999; Wasylikowa 1992; 1993; Mercuri 2001). A similar pattern of wild grass exploitation is seen from sites in south western Egypt including Nabta Playa in the early Neolithic (Wasylikowa, Harlan *et al.* 1993; Wasylikowa, Schild *et al.* 1995; Wasylikowa 1997) and at Hidden Valley Village, Farafra Oasis (Barakat and Fahmi 1999) and Eastpans, Abu Ballas Ridge (Barakat and Fahmi 1991) in the mid to late Neolithic. Small seeded grass species dominate the assemblages from the Egyptian sites including *Echinochloa* cf. *colona*, *Panicum* cf. *turgidum,* wild *Sorghum* spp., *Digitaria* sp., *Setaria* sp., *Brachiaria repens, Urochloa* sp. and

Pennisetum/Cenchrus sp. (Wasylikowa 1997; Barakat and Fahmi 1999). The Akakus and Eastern Saharan sites suggest broadly similar patterns of wild grass exploitation continued across the Sahara until the end of the Holocene wet phase.

Significantly neither the Egyptian nor the Fezzanese sites indicate any *in situ* domestication of crops. Archaeobotanical evidence for the cultivation of emmer wheat and barley in the Nile Valley suggests agriculture reached the Fayuum basin by the late 5th millennium BC at Fayuum and Merimde (Hassan 1984; 1985; 1986; 1988; Wetterstrom 1993). The first evidence for agriculture in the Fazzān and indeed Libya is also based on the Near Eastern crops of emmer wheat and barley with perennial fruits recovered from early first millennium deposits at the promontory settlement of Zinkekra in the Wādī al-Ajāl (van der Veen 1992; figs. 1.3; 1.4). The material culture of the site exhibits some characteristics suggestive of continuity from Late Neolithic pastoral groups (Daniels 1970b), while the agricultural remains are characteristic of evidence for greater contact with northern and eastern populations. It is likely the population included some migration of Palaeoberbers into the Sahara (Camps 1980; Blench 2001; cf. Brett and Fentress 1996) and some migrants from oases further east towards Egypt (Mattingly 2003) who may have brought with them agricultural and irrigation knowledge, as well as some existing descendants of the pastoral populations. Uranium/Thorium (U/Th) and ^{226}Ra dating suggests that by 3,100 ±125 BP surface water was either very scarce or nonexistent at the base of the escarpment, indicating that the inhabitants of Zinkekra must have already been using some form of irrigation to cultivate their crops (Drake *et al.* 2004). The adoption of agriculture in the Fazzān may therefore be associated with increased aridity in the region and a need for alternative subsistence strategies.

The earliest evidence so far for the domestication of indigenous African crops is recorded from sub-Saharan West Africa for the 1st half of the 2nd millennium BC at widely dispersed sites in Mauritania, Ghana and Mali. Impressions of pearl millet grain dated to c. 3500bp have been recovered from Dhar Tichitt, and Dhar Oualata, Mauritania (Amblard and Pernès 1989; Amblard 1996). A cluster of dates for early pearl millet based on charred grain is now available from sites to the south of the Sahara for the early to mid second millennium BC in Burkina Faso (Neumann 1999; Vogelsang *et al.* 1999) and Nigeria (Klee *et al.* 2000; Neumann 1999), while charred grain has been recovered from deposits dated to 1650-1100BC from Winde Koroji, Mali (MacDonald 1996). Importantly none of these sites has produced evidence for *in situ* domestication; the implication being that pearl millet arrived from elsewhere in a domesticated form. The recent find of cultivated pearl millet from Birimi in Northern Ghana (D'Andrea, Klee and Casey 2001) of more or less contemporary date to those from Dhar Tichitt, Oualata and Dhar Nema (Amblard and Pernès 1986; Amblard 1996; MacDonald, Vernet, Fuller and Woodhouse 2003) in southern Mauritania, some 1000km to the north would indicate that the initial domestication took place sometime earlier. This is also supported by finds of African crops in India from the early 2nd millennium BC (Fuller 2003). Finds of pearl millet within Kintampo subsistence strategies further more demonstrates the inclusion of northern influences within the culture consistent with theories concerning southward migration of Saharan populations.

1.4 The Fazzān: The Physical and Agricultural Setting

Modern day Fazzān is the vast south-west desert province of Libya which broadly extends from the Algerian boarder in the west and the borders of Niger and Chad to the south westwards for about 600km towards Egypt and northwards to the pre-desert zone and the oases of the al-Jufra (Mattingly 2003; figs. 1.1, 1.2). The oases of the region are generally small but concentrated in dense linear bands. Human settlement has traditionally fallen into three broad bands of oases between 24° and 28° latitude running approximately east-west: the Wādī ash-Shati in the north, the Wādī al-Ajāl (also known as the Wādī al-Hayāt) and the Wādī Barjūj/ Wādī 'Utba in the centre, and the Murzuq/al-Hufra and ash-Sharqīyāt depressions in the south (Mattingly 2003; fig. 1.2). A number of outlying oases to the east and the west, including Ghat in the far south west, have at times been closely associated with the Fazzān in terms of social and economic development although not always within the same regional administrative control. The Fazzānī or Fezzanese are traditionally regarded as sedentary cultivators within this geographical region. Three groups of Saharan nomads occupy territories in the wider surrounding region, the Tuareg to the west and south west (Keenan 1977; Nicolaisen and Nicolaisen 1997; Norris 1975), the Tubu to the south-east, centred on the Tibesti mountains (Beltrami 1997; 2000; Chapelle 1980; Cline 1950; Lewicki 1988; Nachtigal 1974) and various Arab nomads to the north (UNESCO 1963; Cauneille 1963; Wright 1989). These mobile groups must have played an important role at various times in forming an interactive bridge between the Fazzānī and sedentary populations on the periphery of the Sahara.

There are two major expanses of sand sea in the region, the Dahān Ubārī to the north of the Wādī al-Ajāl and the Dahān Murzuq to the south of the region. The southern boundary of the Wādī al-Ajāl is formed by a steep escarpment rising 200 to 300 meters to a planar rock desert (Hamada), the Massāk Sattafat and Massāk Mallat. The sand seas and the Hamada form natural boundaries to the wadi which forms a natural east west route through the desert (figs. 1.2; 1.4; 1.5). The vast waterless stretch of desert to the east of the region has resulted in traditional routes into Egypt being directed via a north-easterly direction via the oases of Zala, Awjila and Siwa (Mattingly 2003; Rebuffat 1970 a/b).

The Wādī al-Ajāl, on which this study is centred, is not a true wadi but is a 3 to 10km wide corridor between the Dahān Ubārī and the Murzuk Hamada or Massāk Sattafat, consisting of a plain of gravels, saltpan and mud flat with intermittent ribbon oasis (figs. 1.2; 1.5; 1.6). During the 19th century the groundwater level in the wadi remained very high, at a depth of only 1-2m below parts of the valley floor. During this period the Fazzān is thought to have contained about 100 villages and 3000 irrigated gardens (Lethiellex 1948, 25, quoted in Mattingly 2003, 6) and a sedentary population of c. 30,000 (Nachtigal 1974, 166-69), although population figures vary greatly. An Italian census in 1931 gave a total population of 25,000 while a French census in the 1940s produced a total of c. 45,000 sedentary farmers and 6,000 nomads (Mattingly 2003, 6). The early part of the 20th century appears to be a period of decline with a falling population and deserted villages (Mattingly 2003, 7). Despite, or perhaps largely because of, the introduction of diesel driven artesian wells this element of decline is still seen in parts of the wadi today in the form of dying palm groves (fig. 1.7), the result of falling water tables.

In all arid areas the rate of precipitation is lower than that of evaporation. As a result, the salts and minerals in the soil are brought upwards and deposited on the surface or upper layers (fig. 1.6; Beaumont *et al.* 1976). This is seen across the Fazzān and is particularly noticeable on abandoned cultivated plots. Any successful irrigation must therefore include more than mere supply of water, but must include measures to counteract salinization through soil improvement measures (Fisher 1978). In addition the soils have a very low humic content and rely heavily on the application of manure and other organic material. The easy availability of water through the use of diesel powered artesian wells has increased arable production over recent years (although has contributed to a sharp drop in the water table). A range of cereal and legume crops is cultivated, the use of which varies depending on the success of the harvest. This is very much in the model of a risk buffering strategy where a little of everything is cultivated, including crops with varying tolerances and requirements, so that in the event of one crop underperforming another may do well (Halstead 1989). The staple crops cultivated include barley, wheat, sorghum, pearl millet, maize, gourds, onion, fava bean and cow pea, while fruits including orange and grape represent rarer crops. Arable gardens are concentrated into groups of small cellular plots surrounded by irrigation channels. A system of crop rotation and fallow is practiced. Arable fields or plots are surrounded by palm trees, occasionally other fruit trees or fences or wind brakes of palm fronds to protect crops from inundation of sand and provide shade from the sun. Date palms have traditionally been planted in the depressions where water lies close enough below the surface for their roots to tap it without artificial irrigation (Despois 1946; Lethielleux 1948; in Mattingly 2003).

Ethnographic observation in the Fazzān and the wider North African region is further explored in chapter 8 as a method of presenting possible analogies with which to develop hypothesis concerning past arable activity. This is complemented by observations of early both European travellers and anthropologists working in the area in the mid-20th century, particularly of the Taureg in Ahaggar (Nicholaisen and Nicolaisen 1997; Nicolaisen 1963; Keenan 1977).

1.5 Agricultural Adaptation in Marginal Dry Lands

Some 40 per cent of the Earth's land surface is made up of dry-lands, supporting over one fifth of the world's population (Barker and Gilbertson 2000). The study of past dry-land communities, in terms of both their successes and failures, is not only of importance to archaeologists in understanding past communities but also in terms of the political, ecological, economic and social sustainability of present day and future populations, particularly in the light of current debates on global warming. Much archaeological evidence survives for once prosperous societies operating successfully in now barren deserts, while it is equally true that many societies within dry-lands provide evidence for remarkable longevity.

Within arid environments water availability limits arable choices. However, recent drought related famines in East Africa and more recently in south-eastern Africa, demonstrate that ecological crises are rarely purely climatically driven: they are affected by socio-political events. The understanding of agricultural production in dry-lands must consider both environmental/climatic and social-political developments. The relationship between environments, climate and people are complex (Beaumont 1993). Environmental determinist theories or simple diffusion models are not sufficient for understanding how and why people began farming or why they alter their farming strategies through time, particularly in the case of more 'complex' societies (e.g. Rosen and Rosen 2001). Nor can it be assumed in general terms that a farmer's decision making is necessarily rational, based on biological or scientific fact. Belief systems, past experiences, social and political pressures will all influence the way a farmer reacts to innovations or to crises such as drought. To illustrate this point Barker and Gilbertson (2000) use the well documented example of the wheat farmers of the northern frontier of South Australia who, during the droughts of 1881 and 1884, continued to believe that 'rain followed plough', so persisted in ploughing and tilling in the belief that this would release more soil moisture in to the atmosphere and thus bring the rains (Meining 1962). In any environment it is the perceived benefit of a particular action or crop husbandry method that is critical to whether or not it is adopted rather than the actual benefit itself.

Dry-lands are by definition characterised by low annual precipitation. The impact of low precipitation on the environment will be dependent on temperature, vegetation and evaporation as well as surface or sub-surface availability of water and the human management of the water supply and/or vegetation cover. While precipitation is low in terms of average annual amounts, a major characteristic of many dry-lands is annual variation. In the study area annual average precipitation is 9 mm although variation in annual precipitation can be as much as 300% (Allan *et al.* 1973). Downpours and flash floods can be as devastating as periods of drought, but they also offer a potential resource which may be collected, stored and utilized in some manner. The management of water is therefore a central theme to any study of dry-land agriculture, as is the mismanagement of water, particularly in the case of non-renewable resources.

In North Africa a range of successful irrigation systems have been adopted some of which are still in use today. The simple *shaduf*, a bucket system for lifting water from the Nile directly in to irrigation channels, appears to have been introduced into Egypt during the Eighteenth Dynasty (Erman 1894; Butzer 1976; Eyre 1994). A major innovation which profoundly expanded the growing season and arable capabilities of the Nile was the introduction of the *saqiya* water wheel in the Ptolemaic period, as well as the *tambour* or Archimedes screw, both of which had the capability of providing a continuous flow of water on a large scale (Crawford 1971; Butzer 1976; Watson 1983; Venit 1989; Eyre 1994). The *saqiya* appears to have reached Nubia during the Meroitic period (Edwards 2004), although it was previously believed not to have arrived until the 4th century AD (Trigger 1965; Adams 1977). The major improvements of the irrigation regime in Egypt during the Greco-Roman period had the result of radical changes to methods of crop husbandry as well as the nature of land ownership and land tenure (e.g. Rostovtzeff 1922; Schnebel 1925; Crawford 1971; 1979; Butzer 1976; Garnsey 1988; Bowman and Rathbone 1992; Ruf 1993; Rowlandson 1996). The *foggara* or *qanat* system of tapping underground water sources was used in the Fazzān, Algeria, southern Tunisia, parts of Morocco and some of the Egyptian oases (e.g. Birebent 1962; Boulaine and Boulaine 1957; Castellani 1999; Goblot 1979 particularly on origins; Keenan 1977; for an overview of the Fazzān *foggara* see Wilson and Mattingly 2003). The *foggara* are discussed in more detail in chapter 2. In Roman and Byzantine Tripolitania a system of trapping and utilizing floodwater by a series of cross-wadi walls and sluices greatly enabled expansion of agriculture to take advantage of market demands within the Roman world (Barker *et al.* 1996; Gilbertson *et al.* 2000).

The impact in terms of agricultural potential of these irrigation systems must have been great, yet their construction and maintenance would have required a considerable degree of social co-operation. This is perhaps particularly so in the case of the *foggara*, the construction and maintenance of which would have been labour intensive and dangerous. The association of increased agricultural intensification and urbanism are frequently related to the introduction of more sophisticated irrigation (for example Merv, Turkmenistan: Nesbitt and O'Hara 2000), although whether the construction of such systems is driven by an existing move towards intensification or actually creates that intensification is debatable. The collapse of more complex systems such as the *foggara* of the Fazzān may equally be linked to socio-political developments, both in terms of cause and effect.

Both short term and long term fluctuations in climate and precipitation must be taken into account in any discussion concerning adaptive strategies in dry lands. The long term sustainability of communities must involve flexibility in terms of avoiding risk (climatic and social/political), that is providing buffers for and coping with periods of adversity. Strategies to buffer against the risk of crop failure might include the cultivation of a broad range of crops, or the routine production of a surplus or goods for trade for the acquisition of resources not locally available, and are frequently an integrated part of the arable strategy in marginal environments (e.g. Forbes 2002; Halstead 1989). The potential significance of risk buffering strategies is highlighted by the suggestion of a link between routine production of a surplus as a risk buffer and the rise of a social elite in Bronze Age Thessaly, Greece (Halstead 1989). Exploitative adaptations may equally form an integral part of a marginal arable existence. For example the short term cultivation of plots of land and the selling of truffles in wet years by nomadic pastoralists as witnessed in the Libyan desert after winter rain in 2001 (author's own observations). As an economic exploitative adaptation Romanised Libyans participated in the Roman economy through an increase in intensive agriculture in the pre-desert of Tripolitania (Gilbertson *et al.* 2000; Barker *et al.* 1996). The pattern of agricultural adaptation in arid environments should not be seen as either universal or in terms of a single evolutionary pathway, for example from extensive to intensive systems, but rather one of continued strategic modification.

In addition to the impact of climate change on local environments, the impact of human agents on desertification and its consequences must be considered. This might include the localised salinization of soil due to over use of irrigation, soil depletion and associated declining crop yields, the exhaustion of non-renewable water sources, the depletion of local vegetation or timber and the spread of disease. Land degradation is often a theme in studies of intensive agricultural systems, from temperate and arid regions. Soil depletion in relation to salinization due to over irrigation is a recurrent theme in the study of ancient Mesopotamia and its failings (Jacobsen and Adams 1958). However, there is also increasing evidence to suggest that ancient farmers practiced soil management which avoided salinization (Powell 1985). Late Sasanian (3^{rd}- 7^{th} Centuries AD) Merv, Turkmenistan, relied heavily on irrigation, but produced continued evidence for the cultivation of a range of plants, including salt sensitive species such as almond and peach, for long periods, suggesting the problems of salinization were largely overcome (Nesbitt and O'Hara 2000). While the impact of some aspects of desertification must be devastating and long-lived, other aspects may be reversible and short-lived. Equally, increased human activity in arid environments must not be assumed to be inevitably detrimental to the environment.

1.6 Agriculture and the Rise of Complex Societies in Africa: Differing Perspectives

Renfrew states that 'no complex society can function unless the level of subsistence production is sufficient to feed a range of specialists, including the leaders and organisers, in addition to those engaged in food production' (1989, 265). While this must be true, the degree to which production drives the development of complex societies is more difficult to unravel. Equally the definition of 'urban' or 'complex' societies are not clear-cut and may have different interpretations amongst European or Mediterranean and sub-Saharan

African archaeologists. The perceived role of agriculture or agricultural surplus in the development of complex societies is seen very differently in sub-Saharan African than in the north and Nile Valley. It is an aim of the current study to assess the applicability of models for the relationship between agriculture and urbanism in the Fazzān on the basis of archaeological evidence.

A recurring theme of Eurasian archaeology is the role of production and control of arable and other surplus, or 'staple finance' (D'Altory and Earle 1985), within the evolution of elites and increased social complexity. Wealth is associated with the control and re-distribution of surplus, and complex societies tend to assume some sort of centralised bureaucratic control. This is particularly so in the case of Pharonic Egypt. Theories concerning increased intensity of production have generally drawn from ethnographic and anthropological models, particularly from Polynesian or Malaysian examples (e.g. Sahlins 1957; Stone 2001; for an overview see Netting 1974).

Within sub-Saharan African it has become clear that such Eurasian (or Polynesian chiefdom) evolutionary economic models do not necessarily apply. A key theme in much African research has been the co-occurrence of vertical hierarchies with multiple, horizontal ritual associations (lineages, secret societies, cults, age grades and so on) and notions of ritual power and leadership (as opposed to financial or military power). The lack of centralised, structured political or social systems, for example the 'Segmentary State' (Edwards 1998; Southall 1988; 1991) is also frequently discussed. Of particular relevance to archaeobotany and subsistence systems is the control of staple surpluses and prestige wealth ownership within complex societies and associated social hierarchy. Several authors have noted the low incidence of economic stratification in African societies based on agriculture, and hence proposed that this was linked to the large scale availability of land but shortages of labour, thus the economic stratification based on access to and control of scarce land rarely developed (Goody 1971, 1976: 111-13). Connah conversely has suggested that the control of unusually productive land was significant in the origins of social complexity (Connah 1987). A distinction has therefore arisen in African economic understanding between 'wealth-in-things' and 'wealth-in people', or 'the imaginary means of production' (Southall 1991). This might still encompass food production in terms of the ability to produce food, be it derived from real or mystical powers. The Alur, the model for Southall's segmentary state, recognised the greatness of their early kings in his ability to make rain and provide food, drink and entertainment (Southall 1956; 1991). The role of food, and particularly beer, as a medium of communication and for enhancing social relations is central to many studies of contemporary traditional African societies (e.g. Arthur 2003; Douglas 1984; Douglas and Isherwood 2001; Goody 1982). It is within this role that imported prestige goods such as wine may be of significance as has been suggested for Meroitic Nubia (Edwards 1996). Rather than through agricultural surplus or land, political power bases are associated with the control or influence of people, and consequently in the capacity to make war and the dominance over trade, particularly of prestige goods, which then takes on particular significance (Hopkins 1973). The functionalist/adaptationist assumptions about the relationship of agricultural intensification, population density and land tenure to political centralization and hierarchies of wealth, power and status are therefore not necessarily applicable (Netting 1990; Shipton 1984; 1994).

The vast and complex diversity seen in African societies (both ancient and current) warns of the danger of using western notions of wealth and the control of production or means of production in model building. However, agricultural change is detectable, even when its causes are not, and the nature of those changes should be identified before making assumptions about subsistence and social structure and development. This thesis will attempt to present evidence for the nature of changes in arable production and food procurement and then explore their possible social implications.

1.7 Detecting Agricultural Change

The current study covers a period of some 3000 years. In addition to tracing the introduction of new crops, it is an intention of the study to trace any changes in the nature of crop husbandry and subsequent treatment of crops within the Fazzān and attempt to explore how such changes (or lack of them) can be related to social structure. In particular changes in the scale and/or intensity of production should be investigated particularly in relation to the economic growth and population expansion of the Garamantian period as indicated by archaeological evidence. The identification and understanding of productive intensification is central to many debates about subsistence change and the development of surplus production and the growth of socio-political hierarchies of proto-urban or urban settlements (e.g. Renfrew 1989; Sahlins 1957; Boserup 1965). It has generally been assumed that in some part agricultural production is linked to the economic success of the Garamantes, which in itself is reflected in the rich (predominantly) Mediterranean cultural artefacts, particularly in the 1st and 2nd century AD. While oasis agriculture must always be intensive in nature, requiring significant irrigation and fertilization, the level of intensity and scale of production before, during and following the Garamantian period is a central issue to this thesis and whether or not such increases can be detected. If any increase in intensity or scale of production can be detected, is this related to population growth (e.g. Boserup 1965), or some other factor such as economic or bureaucratic forces and the emergence of a social elite? Can we detect a decrease in intensity or scale of production in later periods as social cohesion in the region collapsed?

In her influential study, *The Conditions of Agricultural Growth*, Ester Boserup (1965) identified population growth and associated increased pressure on resources as being the driving force behind changes in methods and technology in 'primitive' agriculture in which agriculture was 'developed' towards a more intensive system. While there undoubtedly is a link between population density and agricultural strategies, this link is not necessarily as straight forward as the Boserup model predicts, any more than a link between climate change and subsistence. Social, political and economic aspects of agricultural decision making are not accounted for and the model is based on a rational economic view determined by the underlying principal that the 'law of least effort' will apply and that intensive agriculture is more efficient. In reality farmers will base decisions about agricultural adaptation, new innovations and so on, on a range factors, determined by their own psychology as much as the advantages of the innovation (Bayliss-Smith 1982; Grigg 1970; 1995; Spedding 1988): more important than the economic advantage of a new innovation is the farmers perception of the economic advantage. Furthermore where complex issues of social status, land ownership, risk buffering, ritual, superstition, fear, personal ambition, external and internal political pressures, kinship networks and so on, are at work within a community it may not be possible to simply disentangle agricultural production away from socio-political elements and regard it as merely economic. It is therefore not possible to make simple assumptions about the causes and effects of agricultural change. It may however be possible to map the route of those changes as suggested by Morrison (1994), even within an oasis system of garden agriculture.

Discussion about agricultural change tends to be most easily recognised in terms of expansion or intensification, which tend to be seen as synonymous in the literature. Intensification is in fact only one potential expression of expansion. While the outcome of successful adaptation must surely be increased or improved output, it is important to realise that negative developments may also be detected. This discussion is not purely concerned with expansion and its driving forces, but rather adaptation, be it related to environmental changes, population pressures or socio-political forces. Six principal adaptive strategies, which are not mutually exclusive, but which may be detectable in the archaeological record are suggested:

1. simple expansion (or contraction) of the area of land cultivated and increasing the labour force simultaneously (e.g. due to increased population)
2. shifting the focus of arable production to new locations (this might be associated with a corresponding change in weed flora or physical remains of fields or irrigation systems)
3. increased input of labour, manure, technology or capital investment to the same area of land (i.e. intensification)
4. changing arable regimes that expand the land cultivated without additional labour or other inputs (i.e. extensification)
5. diversification
6. specialisation (i.e. the reduction of diversity).

Strictly speaking, agricultural intensification is taken to mean increased input, into a set unit area of land (a constant), for increased output. 'Intensive agricultural systems are those where the input per area and the returns per area are high, but the return per capita is low (e.g. horticulture, oasis garden cultivation); extensive agricultural systems have low input per area and low return per area, but the return per capita is high (e.g. sheep rearing, large-scale cereal growing)' (Van der Veen and O'Connor 1994). Intensification may involve the modification of the agricultural landscape, for example in terms of the construction of terraces, paddy fields or irrigation systems, or may involve methods that do not leave a permanent impression on the landscape such as increased manuring, crop rotation rather that fallow systems, increased labour or dual cropping. Van der Veen (1992b) has demonstrated the potential for identifying intensive versus extensive agricultural systems through archaeobotanical remains in North East England.

Diversification may be seen as an extensive, primarily risk buffering, strategy in which a 'little of everything is grown', or a range of cultivation plots and techniques are employed. As such this may be regarded as essentially a domestic, subsistence-based production strategy. Where diversity includes the cultivation of non-food as well as food crops, it may be seen as a more intensive system, whereby cash crops are cultivated for inclusion within a market economy, although such cash crops may be intended for exchange for subsistence purposes. Similarly where multiple crops, for example summer and winter crops, are generated by the same piece of land, diversification might be regarded as a form of intensification. Diversification may take the form of

- growing an increased range of crops or crop varieties for risk buffering purposes
- growing an increased range of crops to include cash crops
- staggered planting and harvesting times
- multi-cropping where different seasons are exploited for different crops
- dispersed landholdings in terms of location and size
- varied manuring, irrigation, fallow systems etc.

Increased agricultural specialisation is usually related to participation in a market economy or exchange system. Once production moves beyond a domestic or subsistence base, profit, and by necessity a surplus, is likely to become a principal aim. As such, rapid responses to price fluctuation or new technologies as well as shifting political or social powers are likely to be necessary. Equally the more specialised an agricultural producer becomes the more vulnerable to crop or economic failure he is likely to be. Specialisation may occur

- as part of a household or community-led specialisation for trade purposes to be traded outside the household or community, but still forming part of a subsistence based economy (i.e. a domestic mode of production)
- as part of a shift away from non-domestic modes of production in order to sell commodities through a market. This may occur on a household or community level, for example specialising in sheep rearing or in the cultivation of garden crops or cereals, or in extreme cases one particular type of cereal of vegetable (for example oil seed rape on many European farms today).
- in craft or other industries at the expense of agriculture such as slave trade or copper production, resulting in the participation of a market economy to purchase food. As an extreme example, the quarry settlements in the Eastern Desert of Egypt where agriculture was not possible on any sustainable scale, specialised in the quarrying of granite while most food was imported (Van der Veen 1999b).

By detecting agricultural change and identifying the nature of any change visible in the record it may be possible to hypothesis causes for that agricultural change or to test the extent to which agriculture promoted or supported increased social complexity, particularly during the Garamantian period. Oasis cultivation as practiced in the Fazzān today is by nature intensive and the environmental limitations of the region can be regarded as a constant limiting factor on agricultural output over the past 3000 years (see discussion on climate above). It is an intention of this study to establish if variation in the intensity and/or scale of production over time can be identified or if other adaptive strategies such as diversification or specialization can be detected. If changes can be detected can they be linked to social change and particularly the growth of an 'urban' or 'proto-urban' population at Jarma.

1.8 Food as a Cultural Artefact

Food, and more specifically how we prepare and consume it, is closely associated with identity, be it racial, hierarchical, social, regional or even associated with particular traditions within a particular family. The presence of luxury foods or artefacts associated with their consumption are perhaps the most easily recognised within archaeological deposits, but the methods of preparation and consumption of daily staples, particularly grain products (bread and beer), also have strong cultural associations (e.g. Palmer 2002; Lyons and D'Andrea 2003 ; Edwards 1996b). While it is not possibly to categorically identify the nature of social structure through food remains and associated artefacts the presentation of the relevant data is a valuable starting point in the formation of hypotheses. The identification of cultural traditions where they relate to grain staples, such as bread, couscous or beer, may provide useful evidence about the nature of the introduction of a particular grain type to a region, particularly if it was adopted and absorbed into an existing tradition or if it was introduced as part of a cultural package which might be more closely associated with migrating populations. As such the identification of particular food traditions as well as technology, will produce useful information about the dynamics of the population in the Wādī al-Ajāl as well as social structure.

To support the archaeobotanical data generated from the Fazzān Project the archaeological data are therefore presented (chapter 8) and explored where it relates to food in an attempt to identify cultural change through time as well as aspects of social differentiation (e.g. evidence for luxury foods, conspicuous consumption). Artefacts associated with food and consumption were recovered from both the excavation at Jarma and from field survey as part of the Fazzān Project. In addition material in the stores in the local museum and illustrations in the Charles Daniels archive were examined by pottery and other specialists (Mattingly *forth.* b and c). Much of this work is still on going and the detailed results were not available for study at the time of writing. Reports which were available include the pottery from the survey (Dore, Leone and Hawthorn 2007`), animal bones (Britton & Grant *forth.*) and quern stones (Parton *forth*). In addition, the overview volume includes a report on the burial assemblages in the Wādī al-Ajāl

(Mattingly 2003). The association of artefacts connected with food and drink with mortuary structures is regarded as particularly significant and while must not be taken as purely representative of food consumption in life must surely reflect the importance of certain foods in society as a whole.

1.9 Structure of the Current Study

The current study represents one of the few detailed archaeobotanical studies from the historical period in the central Sahara and as such the data add significantly to the known history of some key crops and are therefore presented in detail. In particular it is used to challenge Andrew Watson's notion of an Islamic 'Agricultural Revolution' (Watson 1983). The data presented have been generated by excavations as part of the Fazzān Project which took place under the direction of Professor David Mattingly in the Wādī al-Ajāl between 1997 and 2001 (final publications in four volumes, Mattingly 2003; *forth.* a/b/c; Interim reports Mattingly *et al.* 2001; 2000; 1999a/b; 1998 a/b; 1997). Interim reports on the archaeobotanical data are given in Pelling 2003 and 2005. The archaeological and historical background is presented in chapter 2. The archaeobotanical methodology is presented in chapter three. The results of the archaeobotanical study in terms of the range and types of plant remains identified is discussed in chapters 4 and 5, while chapter 6 presents the numerical analysis of the data. A macro-regional database of archaeobotanical results from across northern Africa and including that generated during the course of this study, is discussed in Chapter 7. The data generated are used to place the archaeobotanical results from the Fazzān in their wider setting and to trace the diffusion of some significant crops, particularly those discussed by Andrew Watson under his proposed Islamic period 'Agricultural Revolution' (1983). Chapter 8 presents the artefactual and archaeological feature evidence from the excavations at Jarma and wider survey in the Wādī al-Ajāl which will be used to explore cultural aspects of food processing and consumption. Chapter 9 presents some ethnographic observations from the wider region generated by the author while on field work and complemented by published accounts. The final, concluding chapter brings the various lines of evidence together and summarises the evidence for long term agricultural change, adaptation and cultural interaction across the Sahara. The spelling of place names in the Fazzān follows those used by Mattingly (2003) in the Fazzān Project publications and may differ from previously published place names.

Chapter 2
THREE THOUSAND YEARS OF SETTLEMENT AND FARMING IN THE WĀDĪ AL-AJĀL, LIBYAN SAHARA

2.1 Introduction

While the evolution of the distinct north-eastern Saharan desert culture and society is of interest in its own right, it is also significant in terms of wider issues concerning both adaptation to desert environments and the role of Saharan peoples in linking north and sub-Saharan Africa. Past Saharan populations were central to the evolution of an increasingly complex trade network and must also be regarded as a cultural link between north and south. Excavation and survey of Garamantian and later archaeology in the Fazzān region of southern Libya, under the direction of David Mattingly (Mattingly 2000a; 2003; *forth.* a/b/c; Mattingly *et al.* 2002; 2001; 2000; 1999a; 1999b; 1998a; 1998b; 1997; Edwards 2001) has provided a valuable dataset with which to study a long lived and successful desert population. Along with the faunal remains, the botanical remains, which form the focus of the current study, enable the examination of continued agricultural adaptation during a period of nearly 3000 years. This chapter presents a summary of the archaeological and historical background to the region for the period covered by this thesis. The archaeological background is largely derived from studies by Charles Daniels in the 1970s, much of which is being incorporated in the Fazzān Project publications, as well as new data generated by the project (Mattingly 2003; *forth.* a/b/c). The Garamantian period is the period best represented by the archaeological record and the period which is perhaps most interesting in terms of agricultural development and social change. The Garamantes are therefore covered in some detail. The introduction of Islam is clearly of major social significance, although the Medieval and post-Medieval periods represent something of an economic decline. It is beyond the scope of this project to cover the historical development of the Sahara in detail. A table (table 2.1) is therefore presented with a summary of the major historical events and periods of relevance to the Fazzān or the development of arable practices.

Table 2.1 Significant events/periods from 1000BC to the early 20th century in Northern Africa

	FAZZĀN	**Sub-Saharan Africa**	**Maghreb**	**Egypt**	**Nubia**
1000BC	Early Garamantian (c.1000-500BC) Occupation of promontory forts. Agriculture established	Late Stone Age		New Kingdom (1550-1070 BC) 747-661BC Egypt ruled by Kushites (25th Dynasty)	
		9th-5th century Copper Smelting, Mauretania	823 Traditional foundation of Carthage		c 700- 400BC: Napatan (Kushite) period
		c.3rd century BC permanent settlement possible in Inner Niger Delta 200BC first occupation at Jenne-Jeno	7th century onwards Greek settlements in Cyrenaica		c.300 BC-AD 350: Meroitic (Late Kushite) period. Royal cemetery moved from Napata to Meroe. Founding of temples & tombs in savannah hinterland. Founding of settlements in Lower Nubia. Creation of Meroitic script
			146 BC 3rd Punic War, defeat of Carthage, Africa Proconsul created c. 100 BC? Introduction of camel to Saharan Africa	30 BC suicide of Cleopatra, Egypt a Roman province	28BC Romans invaded Nubia 21BC Meroë signed treaty of independence. Roman border withdrawn to north to Maharaqqa
0BC/AD	Classic Garamantian phase (AD1-400) Garama as tribal capital. Imported goods indicate increased contact with Roman Empire especially 1st/2nd centuries AD. Late Garamantian Phase (AD 400-700) Increasing emphasis on defensive structures and decreased imported goods. AD 569 Garamantes sign treaty of peace and conversion with Byzantium – no actual evidence for Christianity	Rise of city states in IND, Jenne-Jeno and Dia	AD 117 Roman Empire reaches greatest extent. AD 193-211 Reign of Septimus Severus	*Spread of saqia in Egypt*	298 AD Roman frontier withdrawn to Aswan *Adoption of saqia in Nubia* (?) 350AD Meroe invaded by king of Aksum (Axum converted to Christianity around this time)
		c.300AD emergence of Ghana Empire of Soninke	AD 285 Administrative separation of Eastern and Western Empire Mass adoption of Christianity	3rd century AD – mass adoption of Christianity	
		Classic Jenne-Jeno 450-1100 AD	c.400 AD Roman loss of Mauretania Tingitana AD 429 Vandals in North Africa AD 435-573 Vandals occupy Tunisia/Carthage. Berber tribes occupy Roman estates beyond Valdal control.		c. 370 AD Separate Nubian Kingdom with royal burials at Qustul/Ballana ca. AD450 King Silko's Greek inscription
500AD			AD 533 Byzantine control of N Africa regained	AD 538 Isis temple at Philae closed	AD 543 Nubia (Noubadia) converted to Christianity

	8th century Ibadi community established at Zuwuila		AD 533 Byzantine control of N Africa regained		AD 569 Dongola (Makuria) converted to Christianity
		Islamic Trans-Saharan trade flourishes Arab Slave Trade, from A.D. 700 to 1911	AD 670 Arab incursions into North Africa Kairouan and Arab province of *Ifriqiya* founded late 7th century	AD639-642 Arab armies conquered Egypt	641-652 wars between Egypt and Nubia. 652 *Baqt treaty* between Egypt & Makuria: Nubians supply slave for grain, cloth & wine 7th century Cathedrals built at Qasr Ibrim & Faras By AD 700 Noubadian merges with Makuria (capital: Dongola)
			AD 740 Berber Revolt across North Africa, break with Damascus	AD 725-832 Declining prosperity and revolts AD868-969 Independence under Tulunids then Ikhshidids	Old Nubian script in use Monasteries founded in Nubia, 7th to 12th Century. AD 956-969 Nubian occupation of Aswan 9th-10th century: first Muslim settlers in Nubia
			Foundation of Fatamid state in Eastern Maghrib. Islam in Western Sahara?	AD969AD Fatimid conquest. Cairo established as capital.	
1000AD	10th century increasing numbers of mobile Arab and Berber groups	c.1000AD Ghana Empire of Soninke (in what is now SE Mauritania) at height of power, wealth from salt and gold. AD 1067 Almoravids destroy Kingdom of Ghana	1055 Expansion of Almoravid territory, driven by famine? 10th -12th century Migration of Banal Hilal and Banu Sylaym into *Ifriqia* Sunni Islam became dominant	1169AD Saladin conquered Egypt. Ayyubids rule. Cultural renaissance, Arabic mystical poetry and Sufism	
	11th or 12th century mosques constructed in the Wadi al-Ajal	1200AD Rise of Mail Empire of the Mande (or Mandinka) peoples in West Africa. Emergence of Hausa city states (Nigeria) 1250 Emergence of Empire of Benin	AD 1152/3 Almohad's take Ifriqia from the Almoravids. AD 1236/7 Ifriqiya an independent state under the Hafsids	1250-1517AD: Mameluke (slave soldier) rule, characterised by great prosperity and well-ordered civic institutions.	
		After 1400 Empire of Songhai dominant in Western Sudan/Niger River valley.			After the 14th century AD, Islam becomes dominant under the Mamelukes.
	14/15th Century defensive wall and Kasbah built at Jarma	15th century Portuguese reach the Gold Coast European Slave Trade begins	14th/15th centuries out break of Black Death and famine	14th/15th centuries out break of Black Death	15th C. Last Dongola monastery abandoned.

1500AD		Late 15th c. to mid- 16th Nomadic Kunta Arabs began to preach and spread mystic Sufi Islam through western Sudan.	16th century Libya part of Ottoman empire	1517 Ottomans defeated Mamelukes	
	18th-19th centuries, period of economic decline as witnessed by early travellers. Malaria rife. Heavy taxes by Turkish officials 1927 Final occupants of Old Jarma moved to new village	1591 Fall of Songhai Empire. Emergence of small kingdoms & increased conflict. Eastwards movement of trans- Saharan trade under the Hausa city-states and the Kanem- Bornu Empire 18th century Height of trans-Atlantic slave trade	Late 19th century/Early 20th century, French occupation of Morocco, Algeria and Tunisia 1911-12 - Italy conquers Libya. 1920s - Libyan resistance to Italian rule begins under the leadership of the Sanusi dynasty and Umar al-Mukhtar	1798 - Napoleon Bonaparte's forces invade but are repelled by the British and the Turks in 1801. Egypt part of the Ottoman empire again. 1859-69 - Suez Canal built. 1882 - 1922 - British rule	By 16th century Muslim kingdom of Funj Sultante established. 1821 northern Sudan under Egyptian control. British interests in Sudan. 1883 – 1898 Mahdists rule 1889 – 1955 Anglo-Egyptian rule.
1927					

2.2 The Garamantes

The Garamantes, centred on the Wādī al-Ajāl in the Fazzān region of southern Libya, were an increasingly dominant power in the central Sahara from c.900BC to 500AD (Desanges 1962; di Lernia et al.. 2002; Mattingly 2003; 2003a; 2003c). Traditionally the Garamantes have tended to be viewed from the perspective of the Roman Empire and the Classical sources, always reflecting a 'Mediterranean' perspective of desert dwellers (Brett and Fentress 1996, 10-80). An alien and nomadic people, they lived beyond the limits of the Roman world and therefore beyond 'civilization'. References in the classical sources tend to be fleeting and vague, but are consistent in their representation of the Garamantes as alien, exotic, savage and uncivilized. Furthermore the classical sources tend to be more concerned with the location of the Garamantes rather than aspects of their society or culture, while the reliance on earlier sources or reference to mythical and magical creatures allows little faith in the reliability of some accounts (Desanges 1980; Mattingly 2003a, 79). In terms of agricultural evidence, with the exception of Herodotus (4.183) the Garamantes tend to be placed with all desert dwellers and regarded as pastoral or nomadic rather than 'civilized' agriculturalists. The travellers tales recounted in Herodotus therefore remain our only contemporary source.

By relying less on historical sources and more on the archaeology, recent work by teams in both the northern and southern Fazzān (Mattingly 2003; Liverani 2000a; 2000b) are beginning to form a more Saharan-centred view of the Garamantes. This work builds on that started by Charles Daniels in the 1970s (Daniels 1968; 1970b; 1971b; 1973; 1977; 1989). In addition to realising the wealth of material culture, and sophistication and extent of irrigation technology, the interpretation of Garamantian civilization as a whole is being reassessed. Importantly, the role of the Garamantes in trans-Saharan trade and as a node in the transfer of goods and ideas between sub-Saharan and Mediterranean worlds is being reassessed (Liverani 2000a; 2000b; Mattingly 2003).

From a Saharan perspective, the Fazzān is at the centre of a regional system and a network of caravan routes from which it provides a link between the Mediterranean world and the Sudanese belt (Liverani 2000a). The current study therefore attempts to place the Garamantes in their central Saharan position and explore their relationship with civilizations both to the north and south of the Sahara, rather than simply as a people on the edge of the Roman world. As Liverani argues (2000a/b), from this perspective the Garamantes were in a position to exploit both the interface between their own and the Mediterranean world and that of the sub-Saharan world, as well as the Nile Valley to the east. It is likely that it is this geographical position, as well as their apparent agricultural success, which resulted in their success as a civilization. It remains the case that by the early first millennium AD, the most visible material culture recovered from excavations of Garamantian sites were Roman, and that the Fazzān is on the periphery of the Mediterranean world from where such goods originate. The relationship between the Garamantes and the Roman world is clearly important. However this need not be interpreted as the Garamantes emulating Roman culture, or as representing the southernmost reach of the Roman Empire, but rather the Garamantes flourishing as a civilisation due to an advantageous relationship with the Roman world and the adoption of Roman cultural artefacts into a Saharan tradition. A full account of the historical and archaeological back ground is given in Mattingly 2003. A summarised account of the major points relating to the current study is given here.

2.2.1 Archaeological Background

By the beginning of the first millennium BC, local populations in the northern Fazzān had adopted a sedentary lifestyle focusing on the Wādī al-Ajāl. The region became the heartland of the Garamantian kingdom, the dominant power in the region until around 500 AD (di Lernia *et al.* 2002; Mattingly 2003). The emergence of Garamantian civilization and settled agricultural existence can be seen in the context of increased aridity towards the end of the second millennium BC and the late Pastoral Period (third-second millennia BC). A marked reduction in rainfall and progressive drying up of small lakes in the landscape of the Central Sahara began c.5000-45000BP (Cremaschi 2001; Brooks *et al.* 2003) culminating in the drying up of springs in the Wādī al-Ajāl by the beginning of the first millennium BC (Drake *et al.* 2004). The increased aridity in this period must have been severely detrimental to the large-scale pastoral economy previously in existence and as a response the late Pastoral period onwards represents a period of rapidly changing lifestyle. An initial increase in mobility and a shift from cattle to sheep/goat herding appears to have been followed by contraction of populations within the oases and the evolution of settled farming from which the Garamantes emerged in the first millennium BC (e.g. Cremaschi and di Lernia 2001; di Lernia *et al.* 2002; Liverani 2000a; Mattingly 2003). Increased mobility in relation to evolving trade networks for the acquisition of resources is also believed to be a characteristic of the late Pastoral period (di Lernia *et al.* 2002; Liverani 2000a). While we lack archaeological evidence for the material culture of the transitional period, the funerary monuments, rock-art and Egyptian depictions of Libyans, are suggestive of a period of accelerated change with increasing social differentiation and the emergence of elites (Di Lernia *et al.* 2001, 292-302; Mattingly 2003c, 339).

The Garamantes or proto-Garamantes are first identified from the beginning of the first millennium BC based on cultural artefacts and settlement sites such as the promontory settlement of Zinkekra, on the southern escarpment of the wadi (Daniels 1968). By the early part of the first millennium BC agriculture was established in the Wādī al-Ajāl as indicated by botanical remains from Zinkekra (Van der Veen 1992). A sequence of radiocarbon dates from the site gives a calibrated range of 900–400 cal BC (ibid, 2695±100 to 2410±120BP). Clustering of the recalibrated probability curves for these dates places them around 800BC (Mattingly *et al.* 2002, 12). The site exhibits a material culture which shows the transition from Late Neolithic pastoralists into a sophisticated irrigation-based culture (Daniels 1970). The botanical remains conversely suggest the presence of agriculturalists from the beginning of the sequence, who cultivated not only cereal crops but also perennial fruits, suggesting that agriculture was well established by the beginning of the occupation represented or that it was introduced by experienced agriculturalist from elsewhere. Uranium/Thorium (U/Th) and ^{226}Ra dating suggests that by 3,100 ±125 BP surface water was either very scarce or nonexistent at the base of the escarpment (Drake *et al.* 2004), indicating that the inhabitants of Zinkekra may have already been using some form of subterranean irrigation to cultivate their crops, although no physical evidence has yet been identified.

As an ethnic group it is believed that the Garamantes represent a mixture of indigenous pastoralists and 'palaeoberbers' (non-negroid, Mediterranean peoples) who migrated into the Sahara during the last two millennia BC (Camps 1980; Brett and Fentress 1996; Muzzolini 1984). Blench in fact argues, based on linguistic grounds, that Berber populations, and consequently Berber languages, may have been highly mobile for some 7000 years, constantly migrating across North Africa and repeatedly encountering each other, thus resulting in a relatively undiverse language family (now largely obscured by Arabic) across a large area (Blench 2001). As Mattingly points out (2003, 434), the presence of migrating Berber populations need not imply a wholesale influx of new peoples but could simply involve small groups of migrating farmers, possibly moving in response to pressures in the Eastern Sahara.

The arrival of new migrating populations is suggested by changes in rock art, for example the depiction of new physical human types alongside earlier indigenous types (Lutz and Lutz 1995; Smith 1992; van Albada and van Albada 1993) and an apparent westward diffusion of horse and chariot depictions from the Nile (Barker 1989; Camps and Gast 1982; Lhote 1982). Skeletal data further support the notion that the Garamantes included both Berber and Negro types (Chamla 1968, 192-94; Sergi 1951). Aspects of the funerary architecture of the Garamantian period suggest traditions adopted from outside the region were incorporated into indigenous traditions (figs. 2.1; 2.2; Mattingly 2003).

The settlement pattern which emerged during the Garamantian period reflects the increasing shift of farming activity to the centre of the wadi floor (fig. 2.3). An extensive system of large settlements or 'towns' surrounded by numerous villages or hamlets emerged, spread along the length of the depression. Vast numbers of cemetery sites are visible at the foot of the escarpment corresponding to the settlements. The Garamantian capital evolved at Jarma (ancient Garama) where occupation is broadly dated from 400 BC to AD 1935. Excavations at Jarma, in addition to survey in the wider area, have produced important evidence concerning the prosperity and sophistication of Garamantian society, as well as their economic and political power (Mattingly 2002; 2003). The prosperity, widespread influence and long term successful occupation of Jarma is attributed to a successful agricultural regime and trade. This was a period of dramatic change in the Fazzān and a cultural apogee with increased urbanism and social elite, thought possibly to be supported by slave labour (Daniels 1970; Liverani 2000a). It is during this period that population levels reached their peak prior to the modern era and material prosperity of the region was at its highest. At the height of their influence the Garamantes are believed to have controlled a desert territory of c. 250,000 km² (Mattingly 2003c, 351).

2.2.2 Garamantian Material Culture

Aspects of the material culture including burial rites are discussed in detail in Mattingly 2003 (and in Mattingly *forth.* a/b/c). It is sufficient here to highlight the fact that Garamantian material culture exhibits both elements suggestive of a continuation of Neolithic traditions, for example in the lithics and ceramics, and imported elements such as Roman amphorae, fine ceramics and glass wears. Some traditions, such as the use of stele and offering tables in funerary monuments is generally limited to the Wādī al-Ajāl suggesting a local, indigenous tradition (Mattingly and Edwards 2003). Other aspects of the burial rite are more widely seen in the other groups of oases such as the use of red ochre, headrests and imported Roman artefacts.

The excavations at Jarma and the outlying site of Sāniat Jibrīl, and field survey elsewhere in the wadi, have revealed ample evidence of metal working (iron, copper-alloy, gold and silver), in the form of hearths, metal fragments, ingot moulds and crucibles (Mattingly *et al.* 2001; Mattingly 2003; 2003c). Jewellery includes ivory and bone items such as bangles, and in particular beads, the local manufacture of which is well attested by larges numbers of broken fragments, the raw material, and complete beads of glass, semi-precious stones including carnelian, and ostrich shell as well as grooved stone 'bead polishers' (Mattingly 2003c). Local pottery manufacture included a range of distinctive forms as well as jars and *dokhas* which show similarities with forms seen elsewhere in Africa such as Nubia (Leone *forth.*). The hand made wares where they relate to food preparation and consumption are discussed further in chapter 8. In addition a number of terracotta human and animal figurines have been recovered from the excavations which appear to be locally manufactured (Mattingly 2003c; *forth.* c). There is some possible evidence for salt production (Ziegert 1974).

Of relevance to agricultural activities and food preparation are quern stones and mortars which have been recovered from burials in the region as well as from the excavations at Zinkekra and Jarma. A more detailed discussion of quern stones and mortars is given in chapter 8. Rotary quern stones first appear around the 2nd century AD. The transition from saddle to rotary querns is seen in grave deposits at the site of Saniat bin Huwaydi (Mattingly 2003c, 360; Parton *forth.*) and in burials elsewhere in the wadi. The inclusion of quern stones in burials suggests they held some cultural significance which is discussed further in chapter 8. The earliest rotary querns are of basaltic lava and are likely to have been imported from the Roman North (Mattingly 2003c, 360).

Imported Roman goods are particularly noticeable in the cemetery sites of the 1st and 2nd century AD (Mattingly 2003; 2003c). Prominent in the assemblages are wine amphorae and a range of drinking and eating vessels including Italian sigillata, jugs, cups and glass beakers. Other imported goods include oil amphorae and oil lamps. More local elements in the graves include ceramic incense burners, headrests, mats and leather shrouds and beaded necklaces, as well as stone stele and offering tables. Many of the imported elements are also represented in settlement deposits at Jarma (Mattingly *forth.* c) suggesting that while they have some significance in the burial rite they may also have been in regular use. The significance of artefacts associated with food in burial contexts is discussed further in chapter 8.

2.2.3 The *Foggara*

One of the most enigmatic archaeological features in the Wādī al-Ajāl are the numerous remains of long chains of rings of spoil which identify the presence of *foggara* shafts, the local version of the Persian *qanat* irrigation system. Over 500 *foggara* systems have been identified within a 160km stretch of the wadi (fig 2.3) which even if not used simultaneously suggests significant investment in labour for both construction and maintenance. This compares to a total number of 176 *foggara* in the Algerian Tidikelt spread between 14 main groups (Lô 1953 quoted in Wilson & Mattingly 2003, 238). A *foggara* consists of a number of shafts linking a slightly inclined underground channel, which tapped groundwater water from the foot of the escarpment of the Massak and brought it by gravity into the arable plots on the wadi floor (fig 2.4).

The date of introduction of the *foggara* into the Fazzān is difficult to establish, although association with cemetery and settlement sites does strongly suggest they are Garamantian, possibly dating from the end of the first millennium BC (Wilson and Mattingly 2003; Mattingly 2000a; 2000b). *Qanat* systems in Kharga Oasis in the Western desert of Egypt have been dated from at least the second half of the 5th century BC (Wuttmann *et al.* 2000). The *foggara* may have been introduced to the Fazzān from southern Egypt soon after. It is equally unclear when the *foggara* went out of use and indeed why. European travellers in the early 19th century either make no reference to them or refer to them as being the remains of the ancient peoples (e.g. Richardson 1948, 289 in Wilson and Mattingly 2003, 238) suggesting them to have been long abandoned. As an intriguing comparison, the *foggara* in southern Algeria remained in use into the early 20th century. It is not clear if the Fazzān *foggara* went out of use because of a drop in water-table or if it is associated with a change in social or political organisation resulting in a lack of labour for maintenance.

It is not clear how either *foggara* construction and maintenance or agricultural labour and land were organised either during the Garamantian period or later. As Wilson and Mattingly point out (2003, 275) the scale of *foggara* in the wadi, implies a substantial labour force and a sizeable population maintained by the irrigated land. *Foggara* construction might have involved specialised skilled diggers, either as a professional class, as is known in Persia, or specialist *foggara* slaves such as the *haratin* who constructed and maintained *foggara* in the southern Algerian oases until their liberation by the French in the early 20th century (Wilson 2003). It is believed that given the northward trans-Saharan trade of slaves in the recent historic period, trade in human traffic may also have been significant in earlier times (Wright 1998). Herodotus's reference to Garamantians hunting Ethiopian troglodytes (Histories 4.183-4) is usually interpreted as slave raids. The decline of the Mediterranean trading ports in the 3rd century AD appears to have had a direct effect on the trade of the Fazzān, and a significant decline in imported Mediterranean goods. If the markets were affected, including the supply and demand of slaves, this may be associated with the decline in the maintenance of the *foggara* (Wilson and Mattingly 2003, 277).

2.2.4 Garamantian Trans-Saharan Trade

As an economic resource trade is a significant adaptive strategy in arid environments vital for the procurement of different resources as it was known to have been in the Medieval Sahara (di Lernia *et al.* 2002; Liverani 2000a). The Medieval trans-Saharan caravan trade and Saharan settlement pattern as we know it evolved by the mid-first millennium AD and is characterised by localised human settlement practicing horticulture in the oases, reduced pastoral activity and caravan trade crossing the open spaces between based on the domesticated dromedary (Mauny 1961; Thiry 1995). The extent of pre-Islamic trans-Saharan trade has long been a matter of debate (e.g. Wheeler 1954; Daniels 1970a). Liverani (2000a; 2000b) argues that we should look to the Garamantian period for the origins of the medieval period trade and that trade and the evolution of Garamantian culture and polity should be seen as adaptations to the aridification of the Sahara in which pastoralism was no longer possible. The vast array of material goods recovered from settlement site and burials within the Wādī al-Ajāl demonstrate that the Garamantes were able to procure olive oils, wine, jewellery, weapons, glass ware, fine pottery, cast metal objects and so on (Mattingly 2003c). The large volume of imported material in Garamantian contexts, particularly of 1st and 2nd century AD date, would suggest that some thing of value was being exported to the Mediterranean world in exchange. Exported goods might have included surplus agricultural products, particularly dates, salt and natron, gold, semi-precious stones, manufactured jewellery and possibly slaves, wild animals and ivory (Ayoub 1967; Bovill 1968; Daniels 1970; di Vita 1982; Mattingly 1995, 155-57; Mattingly 2003c). Liverani suggests (2000a) that this trade implies an equally important reciprocal trade with sub-Saharan regions, for the procurement of these goods, which they might have traded for salt in particular (Lovejoy 1986) or other goods which are largely invisible in the archaeological record such as agricultural produce.

While evidence for long distance trade routes may be reliably provided by Herodotus (Liverani 2000b), the evidence for trade between north and south of the Sahara is harder to demonstrate. Evidence for contacts between the western Sahel and North Africa prior to the start of Muslim controlled trade in the ninth century is spuriously based on the distribution of chariot rock-engravings and paintings, particularly of 'chariot' and occasional historical records. Pliny the Elder refers to an expedition led by the Roman proconsul Cornelius Balbus against in the Garamantes in 19AD (Pliny 5.35-38). The expedition went on to reach several rivers including one, the Dasibari, interpreted at the River Niger on the basis of the similarity between the name Dasibari and the Songhai world *'Isabari'*, from '*Isa*' (river) and '*Bari*' (big), with '*Das*' meaning 'masters of the river' (Lhote 1960, 131-2 in Insoll 2003). However, the reliability of both the rock engravings in terms of evidence for trade (as well as date) and the historical sources can be questioned and there is a total lack of archaeological evidence on the Niger Bend, or elsewhere in the western Sahel for a Roman or other pre-Arab Mediterranean presence (Dawa 1985; Insoll 1996; Insoll 2003). An exception is provided by beads from the site of Jenné-Jeno, one of which is dated to between 250 BC and 50AD and others to between 300 and 800AD (Brill, 1995; McIntosh and McIntosh 1980; Insoll 2003). Liverani in fact argues that any links between Fazzān and western Sahara are irrelevant given the fact that the Fazzān and Hoggar are competitive rather than complementary, such that the economic decline of the former in Islamic times is coincidence with the rise of the western trade routes through Algeria and Morocco (Liverani 2000a). Trade between the Fazzān and the central Sudan prior to the Arab period is perhaps regarded as more reliable (Insoll 2003). Yet archaeological evidence for any such trade is as yet missing. The southern Garamantian out-post of Aghram Nadharif remains the most southerly source of Roman artefacts in the Sahara (Liverani 2000b). However, in both cases if the Garamantes were acting as middle men, trading with the north for manufactured commodities and south for gold and slaves in exchange of salt they would have controlled passage of goods through their territory and thus limited the number of Roman artefacts travelling south.

The presence of any trade through the Central Sahara would have been greatly aided by the use of the camel. The camel is generally regarded as having diffused westward from the centre of domestication in the Arabian Peninsula into North Africa and the Sahara by the Roman period and subsequently West Africa at a currently unknown date (Bulliet 1975; Wilson 1984; Clutton-Brock 1993). Camel bones are first recorded at Jarma in phases 7 and 6/7 in the 1/2nd centuries AD and increase in number from Phase 6 (130 to 390 AD) (Britton and Grant *forth.*). Camels were kept past their prime meat age supporting their use for transport, although it is not clear if this was the case from the earliest appearance onwards. Elsewhere in North Africa camel is now known to have been present at Qasr Ibrim in Nubia by about the 7th century BC (Alexander 1988; Rowley-Conwy 1988) which does raise the possibility that it was around in North Africa for rather longer than generally believed.

2.3 Post Garamantian Fazzān and the Adoption of Islam

Far less is known about the Islamic period of the Wādī al-Ajāl than the preceding periods. The Arab armies began to make incursions into North Africa from about AD 670 (Mattingly 2003a). Actual evidence for early Islamic cultural penetration into the Fazzān is however slight and largely limited to south-east Fazzān around Zuwuila where an Ibadi community appears to have been established from the 8th Century (Savage 1997, 84 and 153). Western Fazzān appears to have seen a degree of autonomy and continuity of cultural tradition, remaining outside direct control of the evolving political powers of the new Islamic leaders until the 11th or 12th centuries when mosques appear to have been constructed at Jarma (Mattingly and Edwards 2003; Mattingly 2003c). The bone evidence from excavations at Jarma may support the adoption of Islam locally at this point as pig bones, previously fairly common, decline significantly from the 11th century (Bitton and Grant, *forth.*).

This was a period of declining wealth in the region and fragmentation of the earlier Garamantian 'state'. From the 10th century the area saw increasing numbers of mobile Arab and Berber groups, some displaced by the migration of the Banu Hilal and Banu

Salim into Tripolitania (Savage 1997, 118-19). An increasing degree of fortification is apparent in the architecture and settlement archaeology of this period. The standing wall and Kasbah at Jarma have produced dates from the 14th or 15th century (Mattingly *et al.* 2002), although they may represent rebuilding of earlier structures. At the same time the economy was further affected by the establishment of a major trade route through Zuwuila, linking Tripoli with the kingdom of Kanem in Chad. By the 11th century two further trans-Saharan trade routes were established through Southern Algeria from Warqla to In Salah and Timbuktu and from Sijilmasa in southern Morocco to Awdaghast (Law 1967, 181-86; Savage 1997, 153-58; Thiry 1995, 399-448).

Through the post-Garamantian periods the population of the Wādī al-Ajāl and Jarma appears to have declined remarkably, until by the 18th and 19th centuries European travellers remark on the degree of impoverishment, the crumbling and deserted villages, malaria and the fact that the bulk of its agricultural production was taken in taxes and rents by absentee sheiks and Turkish officials (Barth 1857, 143-9; Bruce-Lockhart and Wright 1999; Denham and Clapperton 1826: 169-77).

As mentioned above, it is assumed that the collapse of the *foggara* system of irrigation occurred during the post-Garamantian period, although precisely when is unclear, possibly due to a drop in water table, combined with a decline or change in the available labour in the region (Mattingly 2000a; Wilson and Mattingly 2003). The settlement pattern in the wadi shifted from a fairly extensive pattern of settlements and presumably field systems to one of small groups of settlements, palms and fields clustered around scattered wells. This pattern seems to have continued, accompanied by continued population decline until the introduction of diesel powered artesian wells in the mid 20th century enabled renewed agricultural activity and a greater expansion of settlement.

Chapter 3
MATERIALS AND METHODS

3.1 Introduction

The role of agricultural products as food and/or fodder, and the way in which they have been utilized and integrated into past settlement and subsistence systems, is an important element in understanding the dynamics and functions of past communities. Much focus has been directed at prehistoric sites, particularly in terms of domestication of cereals and the distinction between pastoral and arable settlements. The same issues are equally relevant to more complex societies, particularly where both pastoral and agricultural systems are interwoven, or where complex trade networks and links are important in understanding the dynamics of a site and development of a civilization. Within particularly marginal environments, the procurement of food and agricultural adaptation become central to understanding the survival of a community and the persistence of a cultural tradition. It is these issues that are the subject of this thesis.

This chapter outlines the basic techniques and methods employed in this study. The methods employed in the extraction, identification and subsequent analysis of the dataset are now well established but the particular details employed are stated. Archaeobotanical remains form the core of this study into agricultural development of North Africa, with original data generated from five seasons of excavation in the Fazzān, Libyan Sahara, forming a case study. It is intended that the original dataset will provide a chronological sequence for the Fazzān, charting the introduction of the various crops and the evolving agricultural methods employed. In addition these will be placed in their wider context where they will be considered alongside published and unpublished data from sites across North Africa which has been compiled in a database (discussed in chapter 7).

3.2 The Archaeobotanical Methods

3.2.1 Sampling

Excavations at Jarma were conducted over a period of five seasons (1997-2001), during which an area of c20x15 m was excavated, covering some 2000 to 2500 years of archaeology (figs 3.1; 3.2). The excavation data will be published in detail in Mattingly *forth.* c while interim reports are published in Mattingly *et al.* 2001; 2000; 1999a/b; 1998a/b and 1997. A detailed discussion of the dating, including problems, will be published in Mattingly *et al.* forthcoming.

Ten principal phases have been recognised, within which sub-phases represent minor re-building of the major structures (table 3.1). Detailed descriptions of phases are given in chapter 4 with an overview of the character of samples from each phase. A strategy of total or near total-sampling was adopted, where samples were taken from each well-defined context (floors, room fills, pit fills etc), with multiple samples from large features. Where well defined ash spreads were noted, possibly relating to a localised fire, they were sampled as discrete features. Where the ash spreads were less well defined they were sampled as part of the general layer or spit.

Table 3.1: An outline of the major building phases recognised at Jarma.

Phase	Historical Phase	Tentative Date Range	Principal Feature Types
9-10	Early Garamantian	4th-2nd century BC	Pre-temple
8	Early Garamantian	3rd – 1st century BC	Temple structure
7/7-6	Early Garamantian	1st century BC- 3rd century AD	Large pits containing clay figurines.
6	Classic Garamantian	2nd to 6th century AD	Continued use of temple? Domestic structures. Rich material culture.
5	Late Garamantian	3rd to 9th century AD	Domestic structures
4	Post Garamantian/Early Islamic	?	Domestic structures. Hiatus between phase 5 - 4
3	Islamic	?	Domestic structures? Mosque?
2-1	Early Modern	16th to early 20th century AD	Domestic structures? Mosque? Animal pens.

A single grab sample of a grain deposit was taken from hill fort Tinda B. Samples were also taken from hearths/kilns at Saniat Jebril although they did not produce any plant remains.

Sample sizes were restricted by flotation facilities and by time. In the first season a great deal of desiccated material was encountered which tends to produce a much higher concentration of plant material than charred material. Sample sizes of 2 litres were found to be sufficient. Additional samples of 15 litres were sieved through a 2mm sieve in order to recover rarer items. In all other seasons a standard sample size of 10 litres was taken for flotation. Whole samples were taken from small features such as pots and hearths. In addition a programme of dry sieving through a 4mm mesh was conducted throughout the excavation, where possible of one in every four buckets.

3.2.2 Data Extraction

Desiccated and charred samples were treated in the same way: the desiccated material actually survived sieving and floatation better than the charred material. Due to an erratic and unpredictable water supply the extraction process was designed to use a minimum quantity of water. Samples were first dry sieved through a 0.5mm mesh to remove much of the silt (and to recover small finds, particularly glass beads which tended to disintegrate on contact with water). Bucket flotation was then employed to extract the organic material which was collected on a 0.5mm sieve and dried. The heavy mineral component was collected on a 1mm mesh and quickly sorted by hand for any bone, pot, small finds or remaining plant material. Samples which contained large quantities of ash or dung did not float well so were dry sieved only. Dried flots were brought back to the UK for analysis in laboratory conditions.

3.2.3 Sample selection

A total of 261 samples were collected and processed during the excavation producing flots of variable size and quality. In order to select samples for laboratory analysis all flots were first scanned under a binocular microscope to assess the quantity and quality of seeds and chaff present. The assessment results are contained within an Excel spreadsheet for easy access and provide a basis for broad interpretation of sample patterning. Samples were selected for sorting which contained statistically useful numbers of seeds (generally more than 100) or which were of interest in terms of individual species or for archaeological reasons. In total 62 samples were selected for detailed analysis from the excavation at Jarma with the grab sample from Tinda B (see appendix one for details).

3.2.4 Identification and Quantification

Identifiable seeds, chaff and so on were extracted by sorting the selected flots under a binocular microscope using a small paint brush or flexible tweezers. Identifications are made at x10-40 magnification on the basis of morphological characteristics and by comparison with modern reference material held at the Institute of Archaeology, University College London or by the author. Detailed identification notes are discussed in chapter 5 where relevant. Items are recorded as seed, fruit, nutlet etc or as chaff or straw item (rachis, glume base etc.). Botanical nomenclature follows Miller (1987) for wheat, Zohary and Hopf (1994) for other crop plants and for wild plants follows Ali and Jafri (1976 onwards). Identification data were entered into an Excel spread sheet with numbers of each item/species per sample given which could then be used to generate total counts for samples and species, ubiquities, and ratios of plant parts. Tables generated from the spread-sheet are presented in appendices two (for desiccated remains) and three (for charred remains).

Seeds, fruits, grains etc are recorded as one in the tables. Cereal grains are counted on the basis of embryo ends. This ensures that two or more fragments from the same grain cannot be counted more than once. In the case of desiccated cereals, particularly of barley, the structure of the grain itself has often decomposed, leaving the lemma and palea intact. Where this occurred they are treated as grains and quantified accordingly. Loose fragments of lemma and palea, or glumes, can not be quantified accurately and are recorded as present, common or abundant. They are not included in any quantitative analysis. Date stones tend to fracture readily, often producing many fragments from one stone, so were counted on the basis of ends (i.e. two ends made one stone). This has proved a more reliable method than estimating whole stones, as the more solid ends tended to be better preserved than other fragments. The embryos tended to fall free from the stone and are counted separately. The number of embryos was often lower than the number of stones estimated by stone ends and so was not used for the quantification of the stones themselves and is therefore excluded from the numerical analysis. Other fragmentary seeds are combined and the numbers of whole seeds estimated. Chaff fragments are counted individually as one rachis node or internode, one culm node and so on. Awn fragments are counted but are not included in any quantitative analyses. Weed seeds are counted as one, as are thorns, stem segments, leaves and so on.

3.2.5 Standardisation of the Data

In order to compare samples systematically and to calculate ratios of different plant parts or types it is necessary to use a method of standardisation. The data are then further manipulated to calculate the relative proportions of different plant parts. Quantification is as above. Totals were then calculated for grain, chaff, pulses, fruits and other crops and weed seeds. Other plant parts (leaves, thorns etc.) are not used in the basic ratios but are included in the correspondence analysis. The total for grain is based on embryo ends. The total for chaff includes rachis, glume bases (where 1 spikelet fork = 2 glume bases) or involucres for *Pennisetum glaucum*. In the case of *Sorghum* spikelets were used for desiccated remains, where both spikelets and glume bases were present, while glume bases were calculated for charred remains as spikelets were absent. Pulses are calculated as the total seeds and/or hila. Fruits, spices and other crops were grouped together and the minimum number of seeds was calculated. Total weed seeds is the total number of seeds/whole capsules or nutlets. For the correspondence analysis the data were manipulated further to take account of different levels of identification. This is discussed in detail in chapter 6.

3.3 The Nature of the Evidence

Preservation of botanical remains occurs when the usual agents of organic decay are halted, either by a lack of oxygen or water (as in the case of desiccated remains), or because the organic components have been converted to a stable state, i.e. semi-fossilised carbon. The botanical remains from the sites within the Fazzān Project consist of both charred and desiccated remains, as is the case with sites from across the study area. Waterlogged plant remains are in theory possible from features which are cut to depths below the water table, but in practice this tends to be a preservation type more commonly associated with northern European sites and no such remains were recovered from the Fazzān. Waterlogged material was recovered from the port site of Carthage, Tunisia, (e.g. Van Zeist *et al* 2001) and some material has been recovered from a well at the port site of Lepcis Magna, Libya, but as yet has not been examined. This material is not considered in the statistical analysis of data from across North Africa although identification of cultivated species is considered in the discussion where relevant. Differences in the charred and desiccated assemblages are discussed with consideration to how this affects interpretation of the data. In the statistical analysis of regional wide data, which uses absence/presence of species only, the two preservation types are treated separately and together in order to examine how significantly the data are affected by preservation when examined at this level.

During his work on medieval sites within the Rhine Valley it was noted by Knörzer (1971) that the charred botanical assemblages consistently included the same limited range of plant types and parts, notably the remains of cereal grains and other crop plants, crop processing waste and wild plant species of an ecologically limited range dominated by weeds of arable fields. This has generally proved to be the case from European sites, and hence the majority of analytical studies have concentrated on cereal crops and the ecology of the cultivated environment. With some exceptions, such as alter offerings where in-situ charred remains have been recovered (e.g. at Pompeii, Robinson 2002), non-cereal remains have generally been considered to be casually discarded food items thrown on to fires of ovens, and while they contribute to the list of known economic species, they provide limited scope for critical analysis.

In the assemblages from the Fazzān project and from other sites in North Africa, such as the Libyan Valley sites (Van der Veen, Grant and Barker 1996), non-cereal food remains consistently form a significant proportion of the assemblages. Nevertheless, the very fact that cultivated crops are represented means that the analytical approaches proposed for cereal based assemblages should still be relevant. This will be explored, particularly for persistently present crops such as cotton. This presence of large numbers of non-cereal remains however raises issues about pathways to deposition which are likely to differ from those in northern European contexts. In the current study it is shown that this is a characteristic of the charred as well as the desiccated remains and is therefore not merely a product of preservation. A second characteristic of North African sites tends to be the high proportion of cereal chaff (Van der Veen 1999a). Again this is seen in the Fazzān data in both charred and desiccated samples and therefore needs consideration in terms of the uses of chaff.

As a first step to the analysis of archaeobotanical samples it is important to establish the activities from which they have been generated. The identification of crop processing stages and the distinction between crop products and crop by–products is the first step, not simply as a means to itself, but to filter out any variation due to crop processing. It is then possible to compare like with like, when trying to establish other aspects of crop husbandry such as the use of irrigation or manure. The interpretation of crop processing stages largely derives from ethnographic models. The applicability of standard northern European approaches to identifying crop husbandry activities and the interpretation thereof was an original aim of this project.

3.4 Identifying Crop Husbandry Practices

The identification of crop husbandry practices enables the analysis of botanical remains to be taken beyond mere species lists. As a first stage broad patterns are detected in the data, by eye and by statistical analysis. The broad patterns in the species data may provide an indication of which crops were cultivated when and provide some clues as to the relative importance of the crops. More detailed analysis of the data includes looking at ratios and proportions of the different plant parts or species, or identifying associations of species or plant part. The interpretation of such patterns, in terms of both crop processing stages and husbandry techniques are generally based on ethnographic analogy or on ecological data. It is an intention of the study to test the applicability of the approaches, generally formulated for the analysis of European data, to the study area.

3.4.1 Weed Ecology

Weed ecology, the relationship of weeds to one another and with their environment (Willis 1973), provides a key to unravelling past crop husbandry practices. The physical characteristics of weed seeds will determine their likelihood of being filtered out of harvested crops at the various stages of crop processing. The physical characteristic of the plant will determine whether it is harvested or not (for example low growing species will not be harvested with crops which are plucked or cut just below the ear). The physiological requirements of the plants (ph, nitrogen, moisture requirements etc) will determine their likelihood of occurring in the arable field in the first place, or of being in seed at the time of harvest. However, the weed seeds that are recovered from the archaeological assemblages will only represent a fraction of those that once inhabited the arable plot or field. The filters that act on the weed assemblage range from the weeding and hoeing which might take place in the field, to manuring which may introduce weeds, to the harvesting practices and the various crop processing stages.

Two ecological approaches dominate the archaeobotanical literature, both borrowed from plant ecology: phytosociology, which relies on associations of weed species which persistently occur together in modern stands, and autecology, which relies on the ecological requirements of individual plants. More recently Glynis Jones and others (Boggard, Jones and Charles, 2001; Jones, Boggard and Charles 2000; Boggard, Palmer, Jones and Charles 1999) have proposed the use of the functional morphological/anatomical characteristics of weed species which enable them to perform well in particular situations and can serve as indices of ecological tolerances.

A limitation with any analysis of archaeological weed ecology is the ecological and physiological data available for the species represented in the region of study. No detailed ecological studies exist for the Fazzān beyond the identification of species present and broad habitat information, while plant communities in the Sahara tend to be very broad. No detailed autecological data in terms of ph, nutrient and moisture requirements was available. When examining data from the broader North African region the limitations of ecological data were exaggerated particularly as species behave differently in the extremes of their distribution. Ecological analysis was therefore limited to broad habitat data (desert/steppe, arable weed, maritime species, nitrogen or salt tolerant etc.), flowering season (broadly summer and winter/spring) and physical characteristics (tall, short, armed, big seeded etc). A range of floras were consulted from the region including from Egypt (e.g. Täckholm and Drar 1941-1969; Täckholm 1984; Boulos and Hadidi 1984); Libya (Ali and Jafri 1976 onwards), West Africa (Burkill 1994) and the Sahara in general (e.g. Ozenda 2004).

3.4.2 Ethnographic Models of Crop Processing

Ethnographic studies of cereal harvests and subsequent processing amongst traditional farmers provides us with analogous models with which to interpret the dynamic relationship between humans and the plant species they exploit. The analogy is of value in that the anatomy and nutritional value of crop plants themselves determines the processes through which they are manipulated and adapted for human use. There are relatively few efficient methods of processing crops using non-mechanised tools (Hillman 1981). Each step of processing from harvest to storage and consumption has a measurable effect on the composition of both the crop products and by-products, and the principal components of each of these products and by-products are sufficiently different in their type and relative abundance to be readily distinguished.

Predictive models of specific crop processing activities have been developed through detailed ethnographic observation and sampling of harvests amongst traditional farming communities in Turkey and Greece by Hillman (1973; 1981; 1984) and Jones (1981; 1984; 1987). Both studies involved the formation of sequences through which the crop plant would be manipulated by harvesting technique, threshing, winnowing and so on, detailing which waste products would be generated at each stage, including classes of weeds and chaff, and what the product would consist of.

The consistency of the ethnographic data generated by both Hillman's work in Turkey (1973; 1981, 1984) and Jones's work in Greece (1981; 1984) demonstrated the wider usefulness in the application of ethnographic models to archaeobotanical data. Similar ethnographic studies have been conducted for other crops such as millets in South Asia (Reddy 1994; 1997), finger millet in Africa (Young, 1999), Ethiopian tef (D'Andrea *et al.* 1999) and grass pea (Butler *et al.* 1999). The crucial difference in the processing stages of any of these crops is the difference between hulled and free-threshing varieties.

All cereals and pulses require threshing, to release the seed from its chaff or pod followed by winnowing and sieving to separate the grain from the chaff or pod waste product. Sieving through large and small meshes will separate the grain from the bigger and smaller weed seeds. Hulled cereals, in which the grain is held tightly within tough glumes, require additional processing to release the grain from its chaff, usually conducted at a late stage often immediately prior to use. While smaller millets may not be sieved through a small mesh, the stages are essentially the same for all the cereals.

In theory the presence or absence of the characteristic elements of each stage of processing and the ratios of the various plant parts should enable the identification of that processing stage within a given sample. Hillman suggests the use of ratios of the various elements (grain, chaff, weeds, large weeds, small weeds, light chaff, heavy chaff etc) (Hillman 1973; 1981; 1984). Jones (1987; 1984) demonstrated the applicability of statistical analysis in discriminating crop processing activities on the basis of sample composition. Particularly useful in discriminating processing groups within ethnographic data were weed seed characteristics (aerodynamic properties, tendency to remain in heads and size), a method which does not rely on chaff which tends to survive charring poorly compared with grain (Boardman and Jones 1990). A similar method was applied successfully to archaeological data from the North East of England by Van der Veen (1992b).

The presence or absence of the various stages of crop processing has been applied to archaeological data in an attempt to identify producer or consumer sites, i.e. those occupied by people involved in agricultural production or those who received processed crops. Two basic models have been applied to British data in recent years, the first, proposed by Hillman (1984) based on absence or presence of the early stages of crop processing and the second (M. Jones 1984; 1985) based on overall distribution of plant parts from whole sites, identified grain-rich assemblages as representing producer sites and weed-/chaff-rich assemblages as consumer sites. The M. Jones model in particular has proved problematic for a number of reasons (Jones 1987; Van der Veen 1987; 1991; 1992b; Van der Veen and Jones 2006; Stevens 2003) and is not appropriate to the current study. The internal composition of individual samples is instead examined by using a range of ratios (after Van der Veen and Jones 2006 and Hillman 1981; 1984) as a method of identifying crop processing stages represented at the site. Any differences through phases or feature type can then be highlighted. Detailed discussion of each ratio used is given in chapter 6 with the analysis itself. The details of crop processing activities for the Near Eastern crops (wheat and barley) compared to the African crops (pearl millet and sorghum) are discussed with particular attention drawn to difference in harvesting methods. The applicability of the models is discussed particularly when dealing with the African crops.

3.5 Multivariate Analysis

Numerical analysis of the data is discussed in chapter 6 in detail. In addition to the identification of crop processing activities as discussed above, the analysis of sample composition in terms of site formation processes is further explored by multivariate analysis. The method used is correspondence analysis, an ordination technique used by both ecologists and archaeologists (e.g. Colledge 1998; 2001; 2002; Colledge *et al.* 2004; Lange 1990) which analyses data in a two-way matrix of samples/sites (=cases) and species (=variables) (Greenacre 1984; Shennan 1997, 308-52). Unlike classical statistics which are applied to test hypothesis, multivariate statistics are exploratory methods, used to search for patterns in the data, to summarise the data and reveal its internal structure (Gauch 1984). In correspondence analysis no assumption is made about the distribution of variables in the dataset (Lange 1990) and units and variables (or sites/samples and taxa) are analysed and plotted in the same multidimensional space. The relationship between all variables is therefore analysed simultaneously. Sites/samples and taxa are plotted on 3 or more axis, according to their relative inertia to one another (Shennan

1997). The greatest inertia is usually expressed in axis one and two. Sites or samples that plot closely together can be assumed to have similar characteristics, while sites/samples which plot far apart are assumed to be significantly different. Analysis was conducted using the programme PAST ver. 1.38 (Hammer, Harper and Ryan 2006).

Two sets of analysis were conducted. The charred data produced from Jarma were analysed in order to explore aspects of site formation. All categories of plant remains were included from all samples with more than 50 identifications. By exploring the internal composition of the samples in this manner samples which grouped together can be expected to have been formed by the same processes or can be assumed to be mixed. Samples which plot separately can be assumed to have been formed by distinct processes, and generally are identified as representing single depositional events or a specific processes or deposit type. The second set of analysis involves data from the North African region as a whole including the Sahel zone. The purpose of this analysis is to identify possible pathways of introduction of crops and associated weed communities into the Fazzān. A database was compiled of published and unpublished archaeobotanical datasets from across the region which is discussed in more detail in chapter 7.

3.6 Limitations of the Data

There are several limitations of the archaeobotanical data in terms of the research aims of the project. The bulk of the data has been collected from a single site. A thorough understanding of the agriculture of the Wādī el-Ajāl would require material from a range of sites of different type, status and period. Furthermore, the excavated area represents only a fraction of the area of the settlement of Jarma. Detectable changes through time may be the result of a change of use of that area of the site rather than a result of changing crop husbandry practices and any spatial analysis will be limited. Furthermore there are significant taphonomic issues including re-deposition of material and residual contamination. The research is not intended to provide a definitive study, but rather a model for the potential arable developments of the site and the role of agriculture within the economy and social structure of the Fazzān. It should be regarded as an important first step in tracing the arable history of the region and will provide the background for future research objectives. As a dataset it contributes to and is complemented by existing data from sites across North Africa.

In more general terms there are limitations in the interpretation of archaeobotanical data. As discussed above, a major limitation is the paucity of modern analogous weed and crop data from Libya or North Africa and the reliance on data from either tropical or more temperate regions. While the processing of crops is dictated by the biology of the plant, the treatment of the waste products is not. It has been demonstrated that the waste product of cereal processing (the chaff) is an important commercial commodity in its own right in many arid environments, particularly where fuel or alternative animal feeds may be limited (Van der Veen 1999). Any interpretation of cereal processing activities based purely on European ethnographic data will therefore be problematic. However, the analysis will involve searching for and recognising patterns in the data rather than making assumptions based on particular items or occurrences. The interpretation of those patterns will necessarily involve conjecture as it does in all archaeological interpretation.

Chapter 4
EXCAVATION AND SAMPLE DESCRIPTIONS

4.1 Introduction

This chapter presents a description of the archaeology of the sites sampled as part of the Fazzān Project with descriptions of each major phase at Jarma. Dating evidence is discussed including some of the problems. The samples are described in general terms. More detailed descriptions of seeds and discussion of the species is presented in the following chapter. In this chapter overall botanical composition of each phase is discussed with no consideration of individual samples unless there are particular concerns about dating or integrity. As the purpose of this chapter is merely to characterise each phase in broad terms, all quantifiable plant parts are included which includes those not used in the analysis of individual samples and crop processing activities in chapter 6, such as free-threshing wheat glumes or awn fragments.

4.2 Jarma

The site of Jarma was the subject of archaeological work by Mohammed Ayoub and Charles Daniels in the 1960s and early 1970s (Ayoub 1962; 1967; 1968a; 1968b; 1968c; Daniels 1968; 1969; 1970a; 1971a; 1989). The excavations conducted as part of the Fazzān Project focused on an area immediately to the west of the deep depression left by Ayoub's, largely unpublished, excavations, an area immediately behind a probable temple, where deep stratigraphy was preserved. The main excavation area, referred to as G1, measured approximately 20m (N-S) by a maximum of 15m (E-W) at the upper levels. Instability of section faces resulted in the stepping in of the excavated area towards the lower levels. In addition to removing numerous domestic building phases Ayoub is also believed to have removed a major mosque. It was one of the Fazzān Project's aims to recover any remaining traces of the mosque as well as trace the development of domestic architecture and archaeology.

Ten principal archaeological phases were recognised (table 4.3), phase 10 being the earliest. Sub-phases (early-, mid- and late-) represent minor re-building of the major structures. Two 'intermediary phases' (1 to 2 and 6 to 7) lack architecture but are characterized by several apparently placed pots (1 to 2) or large pits (6 to 7). A more detailed archaeological description of the site and the phases is given by Thomas in Mattingly (*forth.* c).

4.2.1 Dating Evidence

The deep stratigraphy encountered at Jarma and the loose, sandy nature of the deposits, in addition to a reduction in imported, datable artefacts for the Post-Garamantian period, posed a number of problems for dating and phasing the site. Residue contamination is a significant problem as is the cutting of earlier phases by later features. Phasing was established on the basis of archaeological relationships and major building phases encountered (Thomas *forth.*). Absolute dates were established on the basis of pottery and artefact analysis and with a comprehensive programme of accelerator mass spectrometry (AMS) radiocarbon dating (Mattingly *et al. forth.* a.; Thomas *forth.*). The dates discussed here are those which were taken from archaeobotanical samples included in the analysis. In total some 41 AMS samples were generated, of which 32 were derived from archaeobotanical samples analysed. Dated archaeobotanical samples are given in table 4.1 while calibration curves for those samples are given in figure 4.1. Initially samples were dated primarily to answer phasing/dating questions of relevance to the dating of the stratigraphy of the site. These samples were processed at the Oxford Radiocarbon Accelerator Unit (dating sample numbers beginning OxA-). Additional samples were later dated by Beta Analytical in order to establish dates for early occurrences of certain botanical species at the site (sample numbers starting Beta-). The significance of the dates of certain species is discussed in chapter 5.

The material submitted for dating generally consisted of grain or seeds, including *Hordeum vulgare* (barley), *Pennisetum glaucum* (pearl millet) and *Triticum* sp. (wheat) grain, *Phoenix dactylifera* (date) stones and seeds of *Gossypium* sp. (cotton) and Cucurbitaceae (pumpkin/squash/gourd etc). In addition two fragments of cob of *Zea mays* (maize) were submitted from late (phase 1/2) deposits and one fragment of unidentified charcoal. The resulting dates (table 4.1; fig. 4.1) generally confirm the dating of

Lab No.	**Sample**	**Context**	**Phase**	**Material dated**	**Uncal date bp**	**Calibrated date range**
OxA-10288	003	061	1 early	*Cucurbita sp.*	220+/- 55	cal AD 1510 - 1960
OxA-10339	013	065	1 to 2	*Zea mays* cob fragment	95 +/-37	cal AD 1670-1960
OxA-10338	008	082	1 to 2	*Zea mays* cob fragment	161+/-35	cal AD 1660 - 1960
OxA-10341	106	375	3	Cucurbitaceae indet.	812+/-35	cal AD 1160-1290
OxA-10340	105	358	3 late	*Phoenix dactylifera*	122+/-35	cal AD 1670-1960
OxA-12701	117	402	3 mid	*Phoenix dactylifera*	1584+/-28	cal AD 410-550
OxA-10346	364	586	3 early	*Triticum* sp. grain	1554+/-36	cal AD 420-600
OxA-10342	107	376	4 late	*Phoenix dactylifera*	204+/-34	cal AD 1640-1960
OxA-10343	121	391	4 late	*Hordeum vulgare*	1657+/-39	cal AD 250-540
OxA-10344	128	468	4 late	*Hordeum vulgare*	1730+/-37	cal AD 230-420
Beta - 194241	361	535	5 late	*Gossypium* sp.	1600+/-40	cal AD 390-550
OxA-10345	350	572	5 late	*Phoenix dactylifera*	1661+/-35	cal AD 250-540
OxA-10347	366	542	5 late	*Hordeum vulgare*	1776+/-37	cal AD 130-380
OxA-10349	389	652	5 mid	*Phoenix dactylifera*	1269+/-35	cal AD 660-870
OxA-10350	395	655	5 mid	*Phoenix dactylifera*	1285+/-36	cal AD 650-860
OxA-10290	411	607	5 mid	*Pennisetum glaucum*	1930+/-80	120 cal BC - cal AD 320
OxA-10352	401	611	5 early	*Phoenix dactylifera*	1690+/-38	cal AD 250-430
OxA-10354	419	686	6 late	*Phoenix dactylifera*	1657+/-37	cal AD 250-540
OxA-10351	400	661	6 late	*Hordeum vulgare*	1727+/-36	cal AD 230-410
Beta - 194240	400	661	6 late	*Gossypium* sp.	1770+/-40	cal AD 140-380
OxA-10353	414	678	6 mid	*Phoenix dactylifera*	1764+/-37	cal AD 130-390
OxA-10289	405	665	6 early	*Hordeum vulgare*	1670+/-55	cal AD 240-540
OxA-12702	539	824	6 early	*Phoenix dactylifera*	1817+/-30	cal AD 120-330
Beta - 194239	549	846	7 late	*Pennisetum glaucum*	1930+/-40	10 cal BC - cal AD 140
OxA-12703	592	925	7 late	*Phoenix dactylifera*	1856+/-29	cal AD 80-240
OxA-12704	597	963	7 late	*Phoenix dactylifera*	1960+/-30	40cal BC - cal AD 130
OxA-12708	609	978	8 early	Charcoal indet.	2123+/-28	350-50 cal BC
OxA-12712	596	962	9 early	*Phoenix dactylifera*	2133+/-28	350-50 cal BC
Beta - 194242	599	951	9 early	*Pennisetum glaucum*	2160+/-40	360-80 cal BC
OxA-12706	599	951	9 early	*Phoenix dactylifera*	2219+/-29	380-200 cal BC
OxA-12707	610	1009	10 early	*Phoenix dactylifera*	2247+/-31	400-200 cal BC
OxA-12713	598	955	10 late	*Phoenix dactylifera*	2246+/-27	400-200 cal BC

Table 4.1 Radiocarbon dates from the Jarma excavations. Uncalibrated (bp) dates are conventional radiocarbon ages (Stuiver 1977). Calibrated date ranges at 95% confidence level, generated using the program Oxcal v.3.10 (Bronk Ramsey 2005).

Garamantian period deposits as suggested by pottery and small finds, while for the post-Garamantian period they greatly enhance our chronological understanding of the deposits. In addition they provide important evidence for first occurrences of certain botanical species.

The date range and dominant archaeological features of each phase is given in table 4.2 taking into account stratigraphy, artefact and radiocarbon dating methods. Further analysis of the dates using Baysian modelling (by John Meadows in Mattingly *et al. forth.* a.) has produced chronological boundaries of the main phases of activities, show in table 4.3. The dating evidence demonstrates that occupation at the site ranges from the 4th to 1st century BC to the early 20th century AD when the site was finally abandoned.

Phases	Date Range	Historical Phase	Feature Types
1-2	16th-early 20th century AD	Late Medieval/Early Modern	Domestic structures. Animal pens? Period of economic decline.
2		Late Medieval/Early Modern	Domestic structures. Animal pens?
3		Islamic	Domestic structures.
4		Post Garamantian/Early Arab	Domestic structure. Hiatus between phases 5 and 4?
5	3rd to 9th century AD	Late Garamantian	Domestic Structures
6	2nd to 6th century AD	Classic Garamantian	Continued use of temple? Large pits containing clay figurines.
7	1st century BC – 3rd century AD	Early Garamantian	Temple Structure
8	4th to 1st centuries AD	Early Garamantian	Temple Structure
9-10	4th to 2nd century BC	Early Garamantian	Pre-temple

Table 4.2: An outline of the major building phases recognised at Jarma (final dates taken from Mattingly *et al. forth.*).

Clearly there are several anomalies in the dating results, particularly for the phase 3 and 4 dates, while the phase 1 and 2 dates are not easily defined, thus giving a rather broad range. To a certain extent some overlap of dates of sub-phases within individual phases is to be expected, thus the refinement of sub-phases within phase 5 for example is difficult, particularly given the nature of deposits in that particular phase which was dominated by deep organic rich deposits. The dating of samples from phases 4 and 3 appear to be particularly problematic. Two phase 4 samples are rather early, while sample OxA10342 (archaeobotanical sample 04PF/107) is particularly late. The phase 3 samples also include two which appear rather early and one sample, OxA10340 (archaeobotanical sample 03PF/105) is again rather late. The two archaeobotanical samples from which the anomalous late dates were generated (samples 04PF/107 and 03PF/105) were both taken from pit fills and produced somewhat similar assemblages in terms of species composition, although sample 03PF/105 was charred and 04PF/107 desiccated. On the basis of the archaeobotany it is suggested that these samples are contemporary, thus supporting the validity of the AMS dates and therefore suggesting the two pits may have been cut from upper phases but were not recognised during the excavation until encountered in lower phases. In all other cases the anomalous dates are likely to be the result of residual contamination, earlier material being incorporated in later deposits. This therefore raises some concerns about the integrity of some samples and the degree of post-depositional mixing and this must be taken into account during the interpretation of the data. It is not possible to disentangle the degree of mixing of individual samples however, and a certain amount of mixing and residuality is inevitable on a site of this nature.

Event	**68% probability**	**95% probability**
abandonment	cal AD 1770–1880	cal AD 1750–1940
3-2 transition	cal AD 1150–1240	cal AD 1100–1270
4-3 transition	cal AD 1040–1130	cal AD 1020–1170
5-4 transition	cal AD 700–760	cal AD 680–770
6-5 transition	cal AD 350–420	cal AD 310–500
7-6 transition	cal AD 130–220	cal AD 90–260
8-7 transition	90 cal BC–cal AD 30	150 cal BC–cal AD 80
9-8 transition	200–110 cal BC	240–60 cal BC
10-9 transition	350–230 cal BC	370–220 cal BC
Start	480–340 cal BC	600–270 cal BC

Table 4.3 Chronological boundaries between phases at Old Jarma deduced by Bayesian modelling of the dates (from Mattingly *et al. forth.* a).

4.2.2 The Archaeobotanical Samples

A description of the feature types and contexts sampled is given here by phase with a brief note on the major archaeological features of each phase. A full description of the archaeology is given by Thomas (*forth.*). The samples are discussed in chronological order with the earliest phases (9 and 10) discussed first.

4.2.2.1 Phases 9 and 10

Phases 9 and 10 are the 'Pre-Temple Phases' and the earliest features represented at Jarma, excavated in both the main trench area (G1) and the Daniels section/slit trench (G2) and a second trench area G4, originally exposed by Ayoub (1967a; 1968b; 1968c; no date) and Daniels (1977; 1989) (fig. 4.2). The archaeology consists of mud-brick walls with associated surfaces and pits cut into the natural. In phase 9 a possible open courtyard area extended over at least part of the area investigated. Finds from phase 10 were dominated by semi-precious stones and lithic flakes indicative of knapping. In addition 9 beads including a large, possibly Punic, faience bead (SF 2072) were recovered from pit 4034. The limited small finds from phase 9 included semi-precious stones, stone flakes, a bone 'button' (SF2130), a spindle whorl fragment and a pot lid.

Three samples were analysed from phase 10, all three from pit fills. Samples 10PF/583 (context 4033) and 10PF/585 (context 4035) were from the temple area, sample 10PF/598 (context 955) was from the main trench. Four samples were analysed from phase 9 contexts, one from a pit fill (sample 09PF/596, context 962) and three from room fills or surfaces (samples 09F/589, 09S/594 and 09F/599).

The overall number of items presents in the phase 9 and 10 samples was low (total 87 quantified items in volume 80 litres of deposit, or 1.09 items per litre). The relative proportions of the various plant parts/types are shown in fig. 4.4. The majority of seeds and chaff present were charred. Desiccated remains consisted of one *Triticum dicoccum/monococcum* (emmer/einkorn) glume base in sample 09S/594 (phase 9) and some (unquantified) lengths of grass stem in sample 10PF/583 (context 4033, phase 10). Given the paucity of desiccated remains in these phases and the early date it must be considered that these desiccated remains may be contaminants from later deposits, although the identification of hulled wheat would be consistent with these early phases. Charred remains were dominated by crop products with cereal grain forming almost half of the total assemblage for the two phases and fruits, spices and so on forming 25.6%. Cereal species identified were *Triticum dicoccum* (emmer wheat), represented by a single glume base, *Hordeum vulgare* (barley), and *Pennisetum glaucum* (pearl millet). Three fruits were identified: *Ficus carica* (fig), *Vitis vinifera* (grape) and *Phoenix dactylifera* (date). *Gossypium* sp. (cotton) was identified in sample 10PF/585 (context 4035 phase 10), although by rare, small fragments only so may represent contamination from higher levels. Weeds seeds, rare chaff items and occasional leaves/thorns and so on made up the rest of the assemblages for these phases. Pulses were not present.

4.2.2.2 Phase 8

Phase 8 represents the first 'Temple Phase' (fig. 4.3) and consisted of segments of small mud-brick rooms which extended north into the baulk (Rm. 8.3 and 8.4), and apparently open areas (Ex. 8.2 and 8.1), divided by short stretches of mud-brick wall (0847, 0860 and 0936) running parallel to the temple. Finds included semi-precious stones, glass fragments, 'stone grinding tools', beads, clay loom weight fragments and two tile fragments. The largest numbers of finds came from the large external area Ex. 8.1.

Three samples were taken from this period, all of which produced rare plant remains only. Two samples were analysed, both from pit fills (contexts 914 and 943). A total of 83 charred items were identified, including cereal grain of *Hordeum vulgare* and *Sorghum bicolor*, fruit remains of *Phoenix dactylifera*, *Vitis vinifera* and *Ficus carica,* and occasional weed seeds. The proportions of the various plant parts are shown in fig. 4.5, although the low number of total items (36) suggests that no significance can be drawn from the relative proportions of the various plant parts. Such remains are more indicative of 'background noise' rather than of specific activities or deposit types.

4.2.2.3 Phase 7 and 6 to 7

Phase 7 represents a continuation of the 'Temple Phase' (fig. 4.6) and is dominated by the Garamantian temple. The architecture was badly truncated by the large-scale pit digging during phase 6 to 7. In addition to the temple the architecture consists of a possibly significant room / building (Rm. 7.1, wall 0761, and its return 0974), including plastered walls. A large external space (Ex. 7.2) between the plastered building and the Garamantian temple may have been associated with the temple, while in the western part of the trench there was an expanse of packing. Finds included glass and semi-precious stone fragments. Intermediary phase 6 to 7 was characterised by an abundance of pits cut into the compact level packing which generated a large amount of pottery, small finds (glass, semi-precious stone, bone/shell objects, beads, loom weights, tile fragments), faunal data, and well preserved animal and anthropomorphic clay figurines.

Three samples were analysed from phase 7 and 6 to 7, two from deposits within external area Ex. 7.1 (sample 07CF/549 context 846 and sample 07F/553, context 868). The third sample was from surface deposits within internal space Rm. 7.1 (sample 07S/592, context 925). Two samples were analysed from phase 6 to 7 pits (sample 6/7PF551, context 837 and sample 6/7PF569, context 909).

The number of items quantified for these phases, including leaves, thorns and so on, was 1411 for 5 samples or 46 litres of deposit (30.7 items per litre). This represents a huge increase from the earlier phases. All the material present was charred. Weed seeds formed the most numerous category of remains in these phases (39.6%) (fig. 4.8). Chaff formed 21.9%. Cereal grains were rare forming less than 5%, while other crop products formed just over 30%. Pulses formed less than 1%. A range of leaves, thorns and other miscellaneous fragments formed less than 5%. Cereal species present include free-threshing *Triticum* sp. (bread/hard wheat), *Hordeum vulgare*, *Pennisetum glaucum* and possible *Sorghum bicolor* (sorghum). The range of fruit crops is much more diverse than the previous phases and includes *Ficus carica* (fig), *Vitis vinifera* (grape), *Phoenix dactylifera* (date), *Citrullus sp.* (watermelon/bitter apple), *Punica* *granatum* (pomegranate) and *Olea europea* (olive). Fragments of possible *Gossypium* sp. were identified in sample 07CF/549 (context 846, phase 7). Possible *Sesamum* sp. (sesame) was also recovered from sample 07CF/549 although the identification of this crop is highly tentative.

4.2.2.4 Phase 6

Phase 6 consisted of two small mud-brick buildings, one of which was well preserved with internal architecture (Rm. 6.1 and 6.2), and adjacent courtyards containing pits and hearths (fig. 4.7). The buildings and internal architecture were reminiscent of small, presumably domestic buildings seen elsewhere in the area including Sāniat Jibrīl (Mattingly 2003c). An abandonment period in this area of the site separated phases 6 and 5 represented by large dumped deposits of ashy and silty/sandy fills within which the remains of fires were detected. These deposits are interpreted as having accumulated gradually rather than being the result of deliberate levelling. Finds were numerous and included glass fragments, semi-precious stones, stone tools and bone/shell fragments or items, beads, grinding tools, clay figurine fragments and loom-weight fragments. In addition finds of tile, fired hypocaust tile and box flue fragments, painted wall plaster, a marble fragment and part of a stone column provide evidence of Roman architectural influences and hint at the presence of a bath house.

A total of 12 samples were analysed from phase 6. Three samples were taken from fill or floor deposits in Rm. 6.3 (samples 06F/405, 06F/400 and 06F/402 (contexts 665, 661 and 661)). Four samples were analysed from Rm. 6.2 including the fill of a pit (sample 06IF/554, context 871), a post hole fill (sample 06PH/615, context 777) and two from room or floor contexts 765 (samples 06RF/520 and 6RF/521). One sample was analysed from external area Ex. 6.1 (sample 06F/513, context 739). Finally, four samples were examined from courtyard area Ex. 6.2, two of which were from features (sample 06PF/414 from pit fill 678 and sample 06PF/517 from hearth or pit fill 756) and two from dumped courtyard deposits (sample 06F/407, context 674 and 06F/534 from burnt deposit 799).

The number of quantified items for this phase was 2109 charred and 16 desiccated items (177 items per sample or 18.6 items per litre). In addition desiccated light chaff of both *Triticum* sp. (wheat) and *Hordeum vulgare* (barley) was present in varying quantities in some samples, particularly samples 06F/402 and 06F/513. Quantifiable desiccated remains included *Hordeum vulgare* rachis small wild grass chaff and four grape pips. Charred plant remains were dominated by the seeds of cultivated fruits, spices and other non-cereal crops, forming almost 60% of the total assemblages (fig. 4.9). Chaff formed 21.4% and weed seeds 12.8%. Cereal grain formed only a minor component (c.6%) while only 7 pulses were identified forming less than 1% of the total assemblages. Cereals and their associated waste are therefore less significant in overall numbers than other cultivated crops in phase 6. The range of cultivated species is again increased from previous phases. Cereals include *Triticum aestivum* (bread type wheat) and possible *T. durum* (hard wheat), *T. dicoccum/monococcum* (emmer/einkorn), *Hordeum vulgare*, *Pennisetum glaucum* and possible *Sorghum bicolor*. Pulses included a possible *Pisum sativum* (pea) hilum. Fruits identified included numerous *Ficus carica* (fig), *Vitis vinifera* (grape), stones, perianths and embryos of *Phoenix dactylifera* (date), while rarer fruits were *Citrullus sp.* (water melon/bitter apple), *Lagenaria sp.*(gourd), *Punica granatum* (pomegranate), *Olea/Zizyphus* sp. (olive/Christ's thorn) and fragments of *Prunus amygdalus* (almond). Possible *Coriandrum sativum* (coriander) and *Sesamum* sp. (sesame) and several seeds of *Gossypium* sp. (cotton) were also identified.

4.2.2.5 Phase 5

Phase 5 (fig. 4.10) consisted of several clusters of poorly defined mud-brick structures, (possibly consisting of animal pens, domestic dwellings and/or store rooms) around a large open area, Ex. 5.1, characterised by thick, mixed deposits of dumped material including mud brick, large quantities of ash and degraded organic deposits (particularly context 607). A well, which was still present in phases 3 and 4, and thought to have been present in phase 5, was situated in the centre of area Ex. 5.1. Small finds included frequent glass, semi precious stones and items of bone/shell, beads, clay figurine fragments, grinding tools and loom-weights (8 from Ex. 5.1). A change in ceramic types was recognisable during this phase with a progression from closed, amphora-like forms (in plain and painted wares) to open vessels with suspension points (Leone *forth.*). This may indicate a change in eating and cooking habits, towards greater use of open fires.

A total of 17 samples were analysed from phase 5 including 7 from the large spread of deposits within open area Ex.5.1. This area was sampled on a grid and spit system to examine possible spatial and temporal patterning. Unfortunately the author was unable to be present during the excavations and the records were poorly kept. Consequently samples were only examined from the upper two spits. Two more samples from Ex.5.1 were taken from a pit fill (sample 05PF/361, context 535) and an upper courtyard or room fill (samples 05F/363 and 05F/366 context 542). Other samples were examined from fills or dumped deposits in courtyard area Ex.5.3 (samples 05F/386 and 05F/389, both context 652, sample 05S/393 context 654), and a pit fill from possible courtyard area Ex.5.3 (sample 05PF/395 context 655).

Phase 5 is the first phase in which desiccated remains were preserved in any quantity. The total number of quantified items was 439 desiccated and 2828 charred. In addition, one sample (sample 05S/415) from the large spread of dumped deposits (context 607) produced 26 seeds and 10 small fly pupae preserved by calcium phosphate type mineral replacement. Additional single mineralised seeds and fly pupae were recovered from sample 05S/411 (context 607) and sample 05RF/401 (context 611). This type of preservation is usually associated with midden or latrine type deposits and is generally indicative of foul conditions (Green 1979).

The desiccated remains are dominated by chaff (78%) with weeds forming 16.5%. Cereal grain and fruits, spices etc were very rarely represented. Charred remains conversely produced a large number of seeds of fruits, oil crops, spices and so on (42%), of which fruit formed the greatest proportion, as well as weeds (23%) and chaff (23.8%) (fig. 4.11). Cereal grain formed only 9.8% and pulses less than 1%. Quantifiable leaves, thorns and so on formed about 1% of both desiccated and charred remains. The broad figures therefore suggest that cereal processing waste and fruit/oil/fibre remains dominate the samples in this phase.

The cereal species present include *Triticum aestivum*, *Hordeum vulgare* and *Pennisetum glaucum*. The only pulse identified was a possible *Vicia faba* (fûl bean). Non-cereal crop plants were dominated by the fruits as in other phases, with *Phoenix dactylifera* (stones, perianths and rachilla), *Ficus carica* and *Vitis Vinifera* being most numerous. Minor fruit included *Cucumis* sp. (melon/cucumber) *Punica granatum* (pomegranate), *Olea europea* (olive) and fragments of *Prunus amygdalus* (almond). Seeds of *Apium graveolens* (celery) and *Coriandrum sativum* (coriander) were tentatively identified. Seeds and fragments of *Gossypium* sp. were numerous.

4.2.2.6 Phase 4

A possible hiatus in occupation separates Late Garamantian phase 5 and early Islamic phase 4, associated with a change in pottery types. The archaeology consists of a large rectangular room or building (Rm. 4.1) surrounded by small subsidiary rooms and courtyards (fig 4.12). A large expanse of sandy and burnt/ashy fill (0391, 0404) covered the surface of room 4.1 (0512), while some internal features and several possible floor surfaces survived. The phase 3 well cut through the western end of the building. If the well was in operation during phase 4 access to it must have been restricted by the surrounding building. A courtyard or open area (Ex. 4.1) with traces of partition walls, pits, and a large stone/mud-brick oven/fire installation (0489), was situated to the south of the building. Small finds from this phase were dominated by stone tools and included glass, semi-precious stones, beads, a clay figurine fragment and 6 loom-weights. Of the 139 small finds only 19 were found within Rm. 4.1.

A total of seven samples were analysed from phase 4: two from room 4.1 (sample 04S/104, context 365 and sample 04RF/121, context 391), two from the fills of features in the external area Ex. 4.1 (pit fill 376, sample 04PF/107 and oven fill 718, sample 04I/511), two from spreads or dumped deposits in external area Ex. 4.2

(samples 04F/383, context 644 and 04CF/129, context 469) and one from external area Ex. 4.3 from an isolated burnt deposit (sample 04I/128, context 468).

Both charred and desiccated remains were identified, with a total of 784 (13.4 items per litre) desiccated and 2206 (38 items per litre) quantified items. The total proportion of desiccated to charred items by number is therefore approximately one third to two thirds, a much higher proportion of desiccated remains than in phase 5. Desiccated remains are dominated by weed seeds (91.2%) with only occasional chaff, fruit, leaves etc and only one each of cereal grain and pulses (fig. 4.13). The large number of desiccated weed seeds is, however, concentrated in a single sample, sample 04PF/107, from which an erroneous date was generated (seed above, section 4.2.1). Chaff forms the greatest component of the charred remains (47.9% of the total charred assemblage), while fruits, oil crops and so on form 27% and weeds 18%. Grain forms only 7% and pulses less than 0.1% of the charred assemblage. The phase 4 samples therefore appear to be dominated by cereal processing waste and fruits/other cultigens with a large number of desiccated wild seeds in one sample. The proportion of charred chaff is noticeably greater than in the earlier phases. Also noticeable in samples of this phase were large numbers of sheep/goat droppings (both charred and desiccated), particularly in samples 04PF/107 and 04CF/129.

Cereal species identified included *Triticum aestivum, Hordeum vulgare* and *Pennisetum glaucum*. Fruits identified were *Ficus carica, Vitis vinifera, Phoenix dactylifera* (perianth, rachilla, embryo and stones), *Citrullus lanatus* (water melon) and *Olea europea* (olive). Other cultivated remains included one desiccated seed of *Capsicum* sp. (chilli/pepper), seed and capsule fragments of *Linum usitatissimum* (flax or linseed), a single possible *Lens esculenta* (lentil) and a few seeds of *Gossypium* sp (cotton).

The seed of *Capsicum* sp. in sample 04PF/107 is out of place in this phase being a New World species and must therefore represent contamination from upper levels. As discussed above this sample produced a particularly late date (date OxA-10342) and the placing of this sample in phase 4 should therefore be reconsidered. Figure 4.14 shows the proportion of the relative plant parts in phase 4 with sample 04PF/107 removed. The desiccated assemblage is clearly quite different being reduced to only 12 items, 10 of which consist of chaff fragments. The charred assemblage is only very slightly affected and the overall phase 4 assemblage remains characterised by the large proportion of chaff not seen in earlier phases.

4.2.2.7 Phase 3

The phase 3 archaeology was dominated by a large central, possibly public, building consisting of one room or courtyard (Rm. 3.2), around which were a series of smaller rooms, some with internal architecture such as clay bins and possible benches, a well and paved area and a large open area to the west. A cache of clay loom weights in Rm. 3.4 and external area Ex. 3.4 suggests this area was used for storage, although weaving type activity is possible. A pot or *tanur* (0337) and fireplace (0432) in the southern part of external area Ex. 3.1 and a *tanur* in Room 3.7 are suggestive of domestic activity. The western wall of Rm. 3.2 is built up against a very substantial stone wall 0076. Traces of an additional large stone wall to the east and south east of the excavation area are thought to be part of the *sahn* (courtyard) wall of Jarma's central mosque destroyed by Ayoub during his excavations in the 1960s (Ayoub 1962; 1967a; 1968a/b/c). Small finds from this phase included painted pottery, ostrich egg-shell, glass and stone beads with some Roman fine ware (African red slip) rims, presumably residual waste from the lower Garamantian levels, and the caches of loom weights in Rm. 3.4 and Ex. 3.4. Stone tools (grinders, pounders etc) formed the largest category of remains presumably including reused building stone.

Nine samples were analysed from phase 3. Five samples were examined from phase 3-early contexts, two from Ex. 3.5 (sample 03S/364, context 586 NE and sample 03F/367, context 586 SE) and the rest from a mud brick wall (sample 03PF/106, context 385, Rm. 3.6), an ashy spread (sample 03F/102, context 283 Rm. 3.1) and a small fire pit (sample 03PF/303, context 554, Ex. 3.5). Samples were also examined from two phase 3-mid room fills (sample 03RF/108, context 389 Rm. 3.7 and sample

03RF/117, context 402 Rm. 3.3) and two phase 3-late samples from external areas (sample 03CF/046 from 'courtyard fill', context 219 Ex. 3.2 and sample 03PF/105 from pit fill 358, Ex. 3.3).

Desiccated and charred remains were present in very similar numbers in phase 3 (1247 desiccated to 1227 charred items). Chaff formed 42.6% of the desiccated assemblage while weed seeds formed 14.8% and the total cultivated crops seed including cereal grain forming less than 10%. Leaves, thorns, stem segments and so on were also numerous forming 36% of the assemblages. The majority of the desiccated chaff however was present in a single sample, sample 03CF/046 (context 219) which included whole segments of *Pennisetum glaucum* ears, as well as frequent *Tamarix* sp. leaves.

The proportions of the various charred remains suggest a slight change from phase 4 and earlier phases with a marked reduction in the proportion of fruits etc to only 13%. Chaff formed 31.4% while weeds formed 41% of the total assemblage. Grain was rare forming just 8.5% of the assemblage. Leaves, thorns and so on formed 6% of the total assemblage.

Cereal species present in this phase were *Triticum aestivum* and possible *Triticum durum*, *Hordeum vulgare*, *Sorghum bicolor* and *Pennisetum glaucum*. Charred grain of this last species was present in large numbers. Other cultivated species included a possible *Lens esculenta* (lentil), *Ficus carica*, *Phoenix dactylifera*, *Vitis vinifera*, *Lagenaria* sp., *Olea/Zizyphus* sp., *Linum usitatissimum* and occasional *Gossypium* sp. seeds. Two New World plants were identified in this phase, one seed of *Cucurbita* sp. (pumpkin/squash) in sample 03CF/046, and one charred *Capsicum* sp. seed in sample 03PF/105. Sample 03PF/105, taken from a pit, produced a very late AMS date of 1670 - 1960 cal AD (OxA-10340). The possibility that these samples contain occasional intrusive material or derive from phase 1 or 2 features is therefore considered. This is discussed more fully in chapter 6.

4.2.2.8 Phases 1 and 2

The botanical assemblages from these later phases were very similar in character and given the problems of refining the dating and the limited number of samples analysed, they are treated together. The phase 2 archaeology consists of several mud-brick walls representing an incomplete house plan (fig. 4.17) with apparent external areas which lack any clear building plan. Two walls, 0143 and 0144, were constructed of solid stone incorporating large numbers of quern stones. The phase is sub-divided by several remodelling episodes, particularly in the south-western corner. A paved or flagged area in the corner between the perpendicular stone walls 0143 and 0144 appears to have housed an oven or fire at some stage. The paving directly overlies the phase 3 well and may simply be the remnants of a paved area around the well, filled in once the well was abandoned. The southern area appears to have been an external, mainly domestic, activity area and produced evidence for fires and a *tanur* (0167) type oven. A slightly raised, paved area was linked to a sump or drain (0408) by a 2m long stone lined channel (0407). The function of this area is unknown but must have involved water, possibly used for washing or for food preparation, butchery etc. To the south of the paved area, and possibly associated with it, was a possible mud-brick oven constructed within a series inter-cutting pits (pits 22/23). In the northern part of the trench Rms. 2.3 and 2.4 contained a small circular feature and a pounding base may have been associated with grinding grain or other food preparation. Organic rich deposits in this phase suggest some animal penning in parts of the site. Finds from phase 2 were dominated by stone tools (pounders, quern stones etc), largely recovered from a stone wall foundation (context 3017) and the well/oven area.

Phase 1 represents the final abandonment phase at Jarma and comprises one or more dwellings consisting of at least 11 rooms with 3 or 4 possible courtyards or open areas (fig. 4.18). At least two significant periods of expansion are suggested. Courtyards or external spaces were recognised by salt hardened and eroded surfaces, presumably formed due to leaching of salts to the surface. Walls were constructed of chaff tempered, salt hardened, mud brick with some re-used architectural stone. Mud 'plaster' was preserved in patches on some floors and the lower parts of walls. Floors consisted of trampled earth with layers of smeared mud 'plaster'. Multiple floor layers were preserved in some areas. Internal architecture or features were rare. A *tanur* or bread oven (feature 0142) was located in the southern part of courtyard area Ex. 1.5. A plaster base of a possible quern stone platform (feature 031) was situated in the south east corner of Rm. 1.5 while a similar, more degraded feature was located in the south-east corner of Rm. 1.3. Ashy spreads are thought to represent hearths or fireplaces. Some of the western rooms contained straw and sheep/goat dung (e.g. context 041 in Rm. 1.10, contexts 122 and 133 in Rm. 1.11) suggesting they were used as animal pens. Finds included large stone objects, mostly grinding or quern stones, hammer stones, mortars, pounders and rubbers, leather or textile fragments and occasional items of jewellery (beads, bracelet and ring fragments) were also present.

Between phases 1 and 2 a sub-phase was recognised (phase 1-2) which lacked distinct buildings but was characterised by pits and a number of placed pots, some sitting on bases of upturned broken pots. It was not clear whether they relate to phase 1 above or to a real intermediate phase.

One sample was examined from phase 2 late (sample 02CF/047) from the compacted deposits below the surface of Rms. 1.8/Ex. 1.2 (context 81). Three samples were examined from phase 1, all three of which were taken from room fills/floor surfaces (samples 01S/003 and 01S/004, context 061 south and north, Rm. 1.2-1.3 and sample 01S/022, context 052, Rm. 1.4). One sample was analysed from intermediate phase 1-2 (sample 1/2S/048) from a sealed surface (context 115) below a phase 1 wall context 036. In addition the 4mm sieving recovered two cobs of *Zea mays* (maize) from phase 1 to 2 features (pot fill context 065 and burnt floor area, context 082). Both were submitted for AMS dating giving calibrated dates (at 2 sigma) of 1660 - 1960 CalAD.

In the upper two phases desiccated remains outnumber charred items, with a total of 2846 quantified desiccated items to 421 charred items (figs. 4.19 and 4.20). The concentration of desiccated remains is particularly high (112 items per litre). In addition to the quantified remains there were also large amounts of unquantified light chaff, such as highly fragmentary *Hordeum vulgare* lemma and palea or *Triticum* glumes. The majority of the charred remains were concentrated in sample 01S/022. While the numbers of desiccated items were much higher than charred, the actual proportions of the different plant parts were broadly similar. The exception to this was the proportion of leaves which was large in the desiccated material (44%) compared to charred (10%). Chaff formed a significant component in both assemblages, actually forming a larger proportion of the charred remains (35.4% of desiccated and 66.5% of charred assemblages). Weeds were present in modest proportions (11% of desiccated and 5% of charred assemblages) while fruits, oil crops and so on formed 11% of desiccated remains and only 5% of charred, a significantly lower proportion than in the earlier phases. The fact that the charred and desiccated assemblages both reflect this decrease in fruits, oil crops and so on (particularly the fruits), and the high proportion of chaff, suggests that this difference is real and not merely a product of preservation. Both types of remains therefore appear to be dominated by cereal processing waste, while fruits are less significant than in earlier phases.

Cereal species represented in phases 1 and 2 samples were *Triticum aestivum, Hordeum vulgare*, *Sorghum bicolor* subsp. *bicolor* var *durra, Pennisetum glaucum* and, from the 4mm sieving, the New World staple grain crop *Zea mays* (maize). Two other new world species recovered from these final phases were *Cucurbita* sp. (pumpkin/squash) and *Capsicum* sp. (chilli/sweet pepper). Other spices or flavourings were *Nigella sativa* (black cumin) and possible *Cumin cyminum* (cumin). Fruits included *Ficus carica, Phoenix dactylifera* and *Citrullus lanatus*. Large number of seeds of *Citrullus lanatus* and *Cucumis* sp. were recovered from the 4mm and 2mm bulk sieving. *Vitis Vinifera* was present but very rare in these phases. Pulses were rare as in all phases but did include possible *Vigna unguiculata* (cow pea), a species of sub-Saharan origin, *Pisum sativum* and *Vicia faba*. The only textile or oil plant present was *Linum usitatissimum*.

4.3 Tinda B

Towards the western end of the Wādī al-Ajāl is the escarpment site of Tinda B, just to the south of the modern town of Ubari (see fig. 1.2). A Garamantian settlement occupies the hill slope to the front of the escarpment, separated from the main escarpment by a narrow land bridge. The settlement is defended by a stone wall across the narrow land bridge and further walls around the east, west and north sides of the site. In common with other escarpment sites in the wadi, occupation at Tinda dates from the 1st millennium BC (Mattingly 2003). As on other escarpment sites soil cover on Tinda is negligible. A large, charred grain deposit was noted in a hut feature on the top of Tinda by Charles Daniels in the 1970s (unpublished notes). The deposit was still there in 1999 when investigated by Dave Edwards and was therefore collected. A 2.6l sample was dry sieved through a 0.5mm mesh.

A total of 1775 seeds or chaff were counted and identified for the Tinda sample, of which some 1527 consisted of grains of *Hordeum vulgare*. The total number of cereal grains was 1625 or 92% of the total assemblage. Chaff, largely dominated by *Hordeum vulgare* rachis formed 1.9% of the assemblage, and weeds 2.8%. The remaining 3.3% was fruit seeds (*Phoenix dactylifera*, *Ficus carica* and *Vitis vinifera*). This assemblage presumably represents a deposit of fully processed grain burnt with a few contaminants and cereal processing waste which had not been fully removed.

Hordeum vulgare dominated the sample from Tinda B. Grains of free-threshing *Triticum* sp. were also present. Most significant however were nine grains each of *Sorghum bicolor* and *Pennisetum glaucum*. The Sorghum grains were all particularly round and broad, characteristic of race *durra* or *caudatum*. The implications of these finds are discussed in more detail in chapter 5.

Four AMS dates have now been generated for this sample, two on barley grains and one each on *Sorghum bicolor* (one grain) and *Pennisetum glaucum* (two grains). All four dates give a calibrated range of between 350 and 50BC, so confirming an Early Garamantian date (fig. 4.21). The significance of these dates in terms of the species data is discussed in chapter 5. The degree of consistency on these four dates would suggest that they are genuinely contemporary and that this deposit is not contaminated by later deposits, remarkable given its exposed position.

4.4 Preservation

The plant remains recovered from the Fazzān Project excavations are preserved by three very different methods: charring, desiccation and calcium phosphate mineralization. In addition occasional remains of silica skeletons were preserved, a mode of preservation which can occur during charring in reducing conditions. For the purposes of any analysis such remains are treated as charred as the preservation occurs in the same manner. The three principal preservation types occur in very different ways and conditions and consequently have implications for the way in which we interpret their deposition.

Charred botanical remains were recovered from all phases at Jarma and at Tinda. Charring occurs when organic matter comes into contact with fire. As such charring tends to favour denser parts of plants such as grain, seeds, culm nodes. Experiments have demonstrated that grain tends to be preferentially preserved over chaff and that dense chaff of glume wheats tends to survive better than the lighter chaff of free-threshing cereals (Boardman and Jones 1990). The large proportion of chaff seen in all but the earliest phases at Jarma would therefore suggest crop processing waste was present on the site. For items such as fruit seeds or nut shells to be burnt they must have been thrown onto fires or burnt with refuse, or in rare cases burnt accidentally for example in a house fire. Fruits, pulses and so on tend to be less well represented than cereal products and their waste on northern European sites. Conversely, in North African sites, particularly Egypt and Libya, fruits tend to be much better represented, which is seen in the Jarma samples in all phases except phases 1 and 2. The occurrence of large quantities of fruit in particular must in part be a product of different waste disposal and/or fuel use but possibly also differences in diet or domestic activity such as location of fires in relation to eating areas. A detailed discussion of sample formation is given in chapter 6. The charred material was frequently very well preserved showing minimal distortion, although was often very brittle, grains shattering easily particularly during floatation, or in some cases was powdery. It is assumed that the brittle nature of the material is the result of the aridity and the shattering on contact with water the result of the extremes of wet and dry. It is not clear why some grain and charcoal were powdery, but it may be the result of salt damage which was more obvious on the desiccated material (see below).

Desiccated remains tended to be rare in the samples until the phases 1, 2 and 3. Desiccated material recovered in earlier samples is generally regarded to be either intrusive or survived in exceptional circumstances, for example within mud-brick. Desiccation occurs where moisture levels are insufficient to enable bacterial decay of the material. The association of desiccation with the upper phases would therefore indicate either that moisture content within the deposits increased with depth, or may reflect prevailing conditions at the time of deposition, that is a pattern of increasing aridity in the region through time. Moisture levels did appear to increase with depth during excavation of the site and while the water-table has dropped in the region it is known to have remained high in the centre of the wadi until the last century (Wilson and Mattingly 2003). It is thought likely therefore that the absence of desiccated remains in lower levels is due to moisture levels within the deposits at these levels. It is not clear if this is associated with actual height above sea level or the depth below the surface. If the former then desiccated remains would only be expected when archaeological deposits had accumulated to a critical height. If a product of depth below the surface then it might be expected that desiccated remains would be found in sites of a range of dates in the wadi where deep stratigraphy was absent. In sufficient sampling of other sites in the wadi floor has taken place to test this, although samples taken from Sāniat Jibrīl produced no desiccated remains, but also very few charred remains.

It is clear from the relative proportions of plant parts from phases 1, 2 and 3 that desiccation seems to favour certain classes of remains over others. Grain is particularly poorly preserved by desiccation. Where grain is quantified it tends to consist of little more than the epidermis and embryo, the internal structure of the grain having collapsed. In some cases the lemma and palea of *Hordeum* grains were intact enabling grain to be quantified, while the grain itself had disintegrated. While in some cases this may be a reflection of insect attack, very few insects were recovered from the samples and the grain showed few signs of nibbling. It is possible that the molecular structure of the grain disintegrates over time as a result of the extraction of water. Unsurprisingly desiccation tends to favour those papery or leafy parts of the plants which would not survive charring. Chaff in particular, which once ripe has a very low moisture content, appears to survive particularly well. Leaves were also well represented, particularly the small leaves of *Tamarix* sp., as were thorns and occasionally flowers. The preservation of these botanical parts enables some insights into material which actually enters the sites but is not preserved by charring. Much of the desiccated material in the upper deposits was badly damaged by salt deposits which also tended to harden mud bricks and exposed surfaces on the site. Salt panning is a characteristic of parts of the wadi where leaching brings the salt deposits to the surface, particularly after winter rains. No analysis was conducted on the salt deposits on the botanical material but it was presumably brought to the surface in the same way. The effect on the material was to crumple it and in some cases corrode it. It is therefore probable that the salt had actually destroyed some of the desiccated remains.

The final form of preservation present is that of calcium phosphate mineralization. Organic material appears to become mineralized when present in deposits with calcium and phosphates in solution, and consequently tends to be closely associated with sewage type or faecal deposits, particularly in cess pits (Green, 1979). The presence of occasional mineralized seeds in the Jarma material may therefore reflect human or animal faecal material and again provides some information about refuse disposal. It is extremely rarely represented at Jarma only present in two phase 5 samples from the large organic rich spread.

4.5 Summary

This chapter has attempted to provide a basic description of the archaeobotanical samples with an overview of the broad patterns seen in the data on a phase by phase basis. No interpretation of individual samples is attempted. The species data are presented as a purely descriptive measure with no significance attached to species occurrence. The broad data patterns highlight two possibly significant trends through time; the decrease in fruits in the upper deposits compared to Garamantian and early post-Garamantian levels, and the occurrence of desiccated remains in the upper levels of the site. The following chapter discusses the species, including weeds, in greater detail with identification notes. The composition of individual samples is explored in chapter 6.

Chapter 5
CHANGING AGRICULTURAL PRACTICE IN THE FAZZĀN: THE PLANT SPECIES

5.1 Introduction

This chapter discusses the changing crop and weed record generated by data from the Fazzān Project, with reference to material recovered from earlier excavations at Zinkekra (Van der Veen 1992). The chapter is primarily concerned with the presentation of the data in terms of species present and also physiological requirements of those plants and the light that sheds on irrigation and agricultural requirements. In the first part of the chapter the crop and weed species present in the samples will be discussed with identification notes and occurrences. Secondly, broad trends through time are discussed. Finally the implications of the cultivation of the various crops are discussed in relation to labour and irrigation requirements. In chapter 7 the implications of the data in terms of what they add to our understanding of the history of the major crops in Northern Africa as a whole will be discussed. Chapter 8 brings the various lines of evidence together and the implications of changing crop species are discussed in relation to social change, population migration and economic development of the site of Jarma and the region.

5.2 The Crop Species

The crop species are discussed by type (winter cereals, pulses, summer cereals etc). Cultivation requirements are also discussed for the various crops and historical background where relevant.

5.2.1 The Mediterranean Winter Cereal Crops

The winter cereals represented include both barley (*Hordeum vulgare*), and wheat (*Triticum* sp.). They are present in all phases at Jarma and at Tinda and form a significant component of most samples, as they do at Zinkekra. Identification follows well established criteria adopted by archaeobotanists working on Old World crops (e.g. Jacomet 2006; Hillman *et al.* 1992; Hillman's unpublished notes and handouts widely in circulation).

Barley is both the most numerically significant cereal represented but also the most ubiquitous, present in all samples and consequently all phases. The large sample from Tinda B consisted almost entirely of barley grains: 1527 items out of a total of 1775, or 92% of the assemblage. In the Jarma samples 404 rachis and 15 whole grains were preserved by desiccation while 1594 rachis and 417 grains were preserved by charring. The barley variety represented in the samples appears to be dominated by a hulled six rowed variety, identified on the basis of cereal grains and rachis internodes. In six-row barley three grains are produced on each node, the central one of which is straight and the two lateral grains are twisted, thus resulting in a ratio of straight to twisted grains of 1:3. In two row barley the lateral grains have disappeared, thus only straight grains are produced. Sufficiently well preserved grain was identified as central (straight), or lateral (twisted), grains to indicate the presence of the six-row variety, although this does not exclude the presence of some two row barley. Only six-row rachis has been identified. The presence of retained segments of lemma and/or longitudinal ridges on the dorsal surface of the grain is indicative of hulled grain, as well as overall angularity. No grain was identified as being naked (characteristics include overall roundness and transverse wrinkles on the dorsal surface).

Both hulled and naked wheat are represented in the samples. The identification of wheat grain to species is problematic, especially in the case of naked grain, and positive identifications are therefore based on the chaff. Wheat grain has a much deeper ventral groove than barley, a steeper embryo and a more pronounced, raised dorsal surface. Grain was identified as naked if it was generally rounded with no sign of longitudinal ridges. Only one hulled grain, which tends to have a flatter or slightly concave ventral surface and signs of being constricted with tightly adhering glumes, was tentatively identified but could not be assigned to species. One hulled wheat species, *Triticum dicoccum* (emmer), is positively identified on the bases of glume bases. The glume bases display a strong ventral keel compared to spelt wheat, but no clear dorsal keel, a characteristic of einkorn. While *Triticum dicoccum* dominates the wheat assemblage at Zinkekra (Van der Veen 1992), at Jarma hulled wheat was rare (5 charred and 3 desiccated glume bases and one possible charred grain) and present in the early phases only (phases 5 – 10), including two desiccated glume bases in phase 5.

The identification of free-threshing wheat (bread and hard wheat) is based on rachis given the inherent difficulties in identifying free-threshing grain to species (Hillman *et al.* 1996; Hillman 2001). Two or possibly three varieties of free-threshing wheat are represented: a bread-type hexaploid wheat (*Triticum aestivum* type), a tetraploid wheat, durum or hard wheat (*Triticum durum*) and a third type which displayed intermediate characteristics, given the label *Triticum X* type. Tetraploid free-threshing wheats are identified by the presence of distinct bulges at the point of glume insertion, trapezoid shape of and the absence of longitudinal lines on the rachis internode where sufficiently preserved. Hexaploid wheats produce rachis with a thin inconspicuous ridge and no bulges at the point of glume insertion, have a shield shaped rachis internode and faint longitudinal lines near the outer edge of the convex face of the internode. In addition the profile of the rachis internode appears to be much thicker and rounder in tetraploid than hexaploid wheats which tend to taper towards the edges and have a much more concave reverse (Jacomet 2006). The intermediate type, *Triticum* X type, rachis (fig. 5.1) had a rachis internode which tended towards trapezoidal rather than shield shape and in some cases was long, was thick in profile and had no longitudinal lines. The rachis node however lacked clear bulges but rather displayed a slight swelling due to remnants of glume base still attached.

Free-threshing wheat was identified from phase 7 onwards (one rachis of *Triticum aestivum/durum*), although was more numerous from phase 6 on. Both *Triticum aestivum* and *T. durum* were identified from phase 6 samples, although in small numbers. The rachis of *Triticum* X type was recovered entirely from one phase 4 hearth sample (sample 04I/128). *Triticum durum* was very rarely positively identified (2 positive charred and 5 desiccated examples and 19 charred and 2 tentatively identified). It was first recorded in phase 6 although given the low numbers of rachis the reliability of its presence in this phase is unclear. It was not recorded at Zinkekra (Van der Veen 1992). Rachis of *Triticum aestivum* was more numerous over all: charred rachis nodes were represented by 135 positively and 17 tentatively identified examples, while 131 desiccated rachis nodes were identified. Numbers of rachis were generally small except in the upper three phases (phases 1-3). Free-threshing wheat grain was identified as charred specimens only and always in low numbers: 17 grains were identified in total.

5.2.2 The African Summer Cereals

The summer (C4) cereals are those which require lengthening daylight and summer rains or equivalent to produce seed. Two major summer cereals have been identified from the Jarma and Tinda samples: pearl millet *(Pennisetum glaucum)* and cultivated sorghum (*Sorghum bicolor* subsp. *bicolor)*. Their presence at the Fazzān sites adds significantly to our understanding of their early history, while their cultivation has profound implications in terms of arable activity and output, and they are consequently discussed in some detail.

5.2.2.1 *Pennisetum glaucum*

Caryopses of *Pennisetum glaucum* were identified from phase 9 onwards. A total of 558 charred and 27 desiccated grains were identified while desiccated involucres were particularly numerous in the upper levels, including entire segments of ear. No wild examples were identified and it is believed therefore that all the *Pennisetum* present is of the cultivated form. A total of 9 grains were also identified from Tinda B. The earliest dated examples of *Pennisetum glaucum* from Jarma have generated an AMS date of 2160+/-40 (Beta – 194242) giving a calibrated date range of 350 - 180BC (68.0% confidence) or 350 – 170 BC (95.4% confidence level). Grain from Tinda B has produced a very similar date of 2130+/-40 BP, calibrated to 195 – 160BC (68.2% confidence) or 200-110BC (95.4% confidence level). Certainly then *Pennisetum glaucum* is present in the wadi at more than one site by the end of the second century BC. It is then recorded at all levels at Jarma and indeed is cultivated in the region today.

5.2.2.1.1 Taxonomy

The taxonomy of the variable genus *Pennisetum* has been described by several authors. The most compact taxonomy is given by Brunken (1977) in which he distinguished the perennial stoloniferous plants, *P. purpureum* Schuamach, from the annual tillering grasses, *P. americanum* (L.) Leeke, which includes the domesticated form and its interfertile wild and weedy races. Brunken divides *P. americanum* into three subspecies: the domesticated pearl millet, *P. americanum* ssp. *americanum*, the wild ssp. *monodii* (Maire) Brunken, and the weedy ssp. *stenostachyum* (Klotzsch) Brunken (known as *Shibras*). *P. americanum* (L.) Leeke is synonymous with *Pennisetum glaucum* (Linn.) R. Brown (Burkill 1985-1997), the most widely used term in the archaeobotanical literature and used in this study.

5.2.2.1.2 Identification

Pennisetum glaucum (L.) R. Br. was generally identified on the basis of charred naked grain and desiccated involucres (phases 1-3 only). In addition, two charred involucres and occasional charred spikelets were present in sample 01S/022, while desiccated grain was present in low numbers in phases 1-3. Identification of grain follows descriptions given by Brunken *et al.* (1977a) and Fuller (2006; *unpubl.*) and by comparison with the reference material. Caryopsis (grain) shape is regarded as more reliable than grain size which can be variable (Neumann *et al.* 1996, 443). Grain was generally obovate (club-shaped), often broadly so, to terete (spherical) with no flattening (figs. 5.2, 5.3 and 5.4). Grain of the wild progenitor (*P. violaceum*), are elliptical to lancolate and dorsally compressed. In some grain the base is narrowed to acute, while the widest part of the grain is at the apex of the scutellum. The scutellum is about ⅓ to ½ the length of the grain. The base of the embryo and the hilum were frequently absent. Desiccated involucres generally retained their stalk (peduncle) which is absent in the wild form (Brunken *et al.* 1977), and occasionally still retained up to three spikelets with fragments of lemma, attached to the involucre by a short stalk (pedicel). The charred involucres consisted of a short fragment of the remaining stalk, and a swollen ball with stumps of broken bristles still retained.

Measurements of caryopses were taken of width, thickness and length with or without embryo according to preservation (see fig. 5.4). (Width is equivalent to breadth and in Zach and Klee, 2003 and Andrea, Klee and Casey 2001). Brunken (1977) gives measurements of *Pennisetum glaucum* caryopses as: Length 1-5.5mm, Width 1.6-3.2mm and Thickness 1.2-2.5mm. All the Jarma grain tended to be small in comparison with modern reference material. Measurements ranged from: Length 1- 2.3mm (0.7 – 2.3mm without embryo), Width 0.5 – 2.0mm and Thickness 0.4-1.7mm. The average Thickness/Width ratio was 86 (T/Wx100). The majority of grain was between 1 and 2mm in length with very few grains being longer. A number of small grain were more dorsally flattened with lower T/W ratios (less than 80) which might be considered to fall within the wild or *shibra* range, although these grains still tended to be club shaped so are regarded as cultivated grain. In modern ears of cultivated *Pennisetum glaucum* the grains are always smaller at the end and the base than in the middle. The large number of very small grains might therefore be indicative of processing waste.

The small size of the grain is a characteristic seen in archaeological material from the sub-Saharan sites of Late Stone Age Birimi in northern Ghana (Andrea, Klee and Casey 2001) and Iron Age Kursakata, North East Nigeria (Zach and Klee 2003). Thickness *vs.* width measurements of the Jarma grain are plotted in figure 5.5 with the ranges of the Birimi and Kursakata archaeological material and Brunken's (1977) measurements of wild, domesticated and intermediate grain (*shibras*) for comparison, as well as the average measurements from medieval Arondo, Senegal (400- 1000AD, Gallagher 1999, taken from Zach and Klee 2003). The Jarma seed data range is comparable to that from Birimi. The average measurement from Arondo suggests the grain to be slightly larger than those from Jarma. Even taking into account some shrinkage due to charring the grain is still clearly smaller than modern *Pennisetum glaucum* grain. No significant size increase is seen in time, with the exception that the phase 2 grain is big. It would appear therefore that the large size of modern grain is a relatively recent phenomena and/or the small size in the archaeobotanical assemblages is the result of processing activities. The difference in size between the Jarma and Arondo grain is slight but is also seen between the Birimi and Kursakata material. This may reflect an increase in time but may also reflect differences in the populations of the grain in the different regions, the Senegalese grain population being of larger size.

5.2.2.2 *Sorghum bicolor*

Perhaps the most significant crop the understanding of the history of which the Fazzān data have contributed is sorghum, although the actual number of grains is low. As for *Pennisetum glaucum* much assumption in the past has been made based on modern wild and cultivated distributions with, until recently, only limited archaeological evidence within Africa. While an east African sub-Saharan origin for sorghum is widely accepted, the timing and origin is still not understood and is the subject of on going debate. While several authors argue for the origins of *Sorghum bicolor* var *bicolor* in the savannah somewhere between western Ethiopia and eastern Chad (derived from subsp *arundinaceum*) prior to 2000BC (de Wet, Harlan and Price 1976; Harlan 1971), others argue for a late domestication of sorghum in north-east Africa (Rowley-Conwy, Deakin & Shaw 1998; 1999; Wigboldus 1990; 1996). The major problem for demonstrating an early domestication has been the lack of reliably identified and dated archaeobotanical finds of domesticated sorghum prior to the beginning of the Christian era.

5.2.2.2.1 Classification and proposed centres of origin

The system of sorghum classification used by most archaeobotanists follows that proposed by Harlan and de Wet (e.g. Harlan & de Wet 1972). All domesticated varieties and their closest wild relatives are of the same species, *Sorghum bicolor*. Cultivated varieties are all of subspecies *bicolor*, of which there are five principal races and numerous half races. The wild sorghum from which they must have derived is subspecies *arundinaceum*, of which there are several races and half races.

The five domesticated races are:

- *bicolor,* the most primitive (fig. 5.8) - a hulled variety which requires an extra stage of processing to release the grain from its glumes. Thought to have been developed some where to the south east of the Sahara between Lake Chad and the Nile, possibly further north given higher precipitation levels in the past.
- *guinea,* which has a restricted distribution in western Africa
- *kafir,* which has a restricted distribution in southern Africa.

- *caudatum* (fig. 5.7) thought to be a later domesticate which originated in the same region as *bicolor* (central Africa/Chad region) but at a later date as it has maintained a more restricted range in Africa.
- *durra* (fig. 5.9) the variety most closely associated with Islamic agriculture, also a late domesticate, believed variously to have developed from *bicolor* in the Indian subcontinent (Harlan and Stemler 1976), in Ethiopia and exported from there to India (Doggett 1988), or possibly in the Nile Valley (Rowley-Conwy *et al.* 1999).

The earliest evidence for domesticated Sorghum however comes from the Arabian peninsular and Indian sub-continent, not Africa. This has lead to the argument for domestication of sorghum at some time before 2000BC (Close 1996; Harlan 1993; Fuller 2003). The African archaeological evidence is discussed in chapter 7 in relation to the new Fazzān data.

5.2.2.2.2 Identification of the Fazzān Sorghum

Two races of *Sorghum bicolor* may be present in the samples from the Fazzān. The charred sorghum in the early Jarma phases and the Tinda B sample is represented by grain only (fig. 5.6). The phase 1 and 2, mostly desiccated material is represented by both grain and glume bases thus making identification more straight forward. In both cases the grain is a broad free-threshing variety. The identification criteria for caryopsis follows Fuller (2006; u*npubl.*). The early Jarma grain is poorly preserved and therefore only tentatively identified. The Tinda B grain is well preserved, enabling identification of possible race.

In all examples the grain identified as *Sorghum* is significantly larger than the *Pennisetum* grain, although smaller than modern examples (length x breadth = 2.2-2.5x 2.0-3.0mm). The grain is ovate to nearly round in plan, ovate or wedge shaped in section, has a long and very wide scutellum (1/3 – 2/3 caryopsis length) and a steep, shallow embryo, much more so than in rounded *Pennisetum glaucum*. A further characteristic of the charred grain is that it appears to have a tendency to explode, with a build up of tarry material around the dorsal end of the grain and some collapsing or shrivelling of the grain itself. The better preserved Tinda B grain is particularly plump with the widest part of the grain in the middle, a characteristic of either race *caudatum* or *durra*. The grain is certainly not of race *bicolor* which is longer than it is broad being constricted by its adhering glumes. The desiccated grain from later phases is poorly preserved, but is still clearly plump and broad, characteristic of *caudatum* or *durra*. The well preserved glume bases display a transverse crease towards the glume base characteristic of race *durra*. It is therefore concluded that the early grain from Tinda, and possibly therefore Jarma, is of race *caudatum* or *durra* (probably *caudatum* given the apparent late evolution of *durra*) and the late Jarma grain (phases 1 – 2) is of type *durra*, the variety cultivated in the region today.

One well preserved sorghum grain from Tinda B was submitted for AMS dating and generated a date of 2180 +/- 40 BP (Beta – 194236) or 370-200 Cal BC (68.2 % confidence), 360-190BC (95.4% confidence level). Accepting that race *durra* is a late variety, it would appear that race *caudatum* was present in the Fazzān by the 4^{th}-2^{nd} century BC.

5.2.3 Legumes

Cultivated legumes are poorly represented in the deposits. A total of 14 desiccated and 30 charred pulses were recorded from Jarma while none were present at Tinda B. Three species of winter sown pulses have been tentatively identified: pea (*Pisum sativum*), bean/vetch (*Vicia* sp.), and lentil (*Lens esculenta*). One summer pulse of sub-Saharan origin was also tentatively recorded, cow pea (*Vigna unguiculata*), present in a phase 6 and a phase 1 deposit at Jarma. Rare indeterminate large legumes were also present. Lentil and indeterminate legumes were identified on the basis of the seed shape, while Pea, *Vicia* sp. and cow pea were identified on the basis of detached hila. This phenomenon was recorded at the UNESCO Libyan Valley Survey's sites (Van der Veen *et al.* 1996) as well as sites in Iraq and Turkey (Butler 1988, Butler in Van der Veen *et al* 1996), and Egypt (e.g. Smith 2003). The hila appears to lift off the seed with a cushion of tissue from beneath it where the seed germinates, taking a rim of testa with it. In some species the characteristics of the testa and shape of the hila are sufficient for identification. *Pisum sativum* has a characteristic round hilum, while *Vicia* sp. has a more lozenge shaped hilum. The seed of *Vigna unguiculata* is sub-rectangular with a triangular cross section which tapers away from the hilum edge (Fuller and Harvey 2006). The hilum is ovate and generally placed asymmetrically on the hilum edge. *Lens esculenta* was identified on the basis of seed shape, being rounded and laterally compressed with tapering edges.

Pulses are generally less well preserved in archaeological assemblages than cereal grains. They tend to come into contact with fire less frequently than cereals and appear not to survive charring so well. They also do not appear to preserve well by desiccation, being affected in a similar way to cereal grains. Occasionally, as in the Jarma samples, the hila and fragments of testa are preserved while the structure of the seed has gone. The fact that a trace of these species is preserved suggests they were being used. They are a valuable group of cultivated crops which fix nitrogen in the soil so increase soil fertility, and provide a valuable source of protein. *Vigna unguiculata* is a crop of sub-Saharan origin. It is not possible to comment on its importance within the economy of the site or the timing of its introduction. As with the other pulses it is likely to be under-represented due to preservation. *Vigna unguiculata* is believed to have been domesticated in West Africa alongside *Pennisetum glaucum* by the mid-second millennium BC (Vogelsang *et al.* 1999, *V. unguiculata*). It has been recorded at Qasr Ibrim from the 4th century AD (Rowley-Conwy 1989). Highly tolerant of heat and drought and a wide variety of soils as long as it is not waterlogged, and quick growing, the cow pea is a useful addition to the summer crops. The plants can produce pods in less than two months and seeds in three. Pods and seeds ripen successively and unevenly, and it can be cut back at an early stage and still produce new shoots. As such, a continual crop of pods or seeds, young shoots and leaves, can be achieved for both animal and human consumption from mid-summer to early autumn.

5.2.4 *Gossypium* sp.

The third summer crop for which the Jarma samples have provided significant new evidence is cotton (*Gossypium* sp.). The remains of a total of 83 *Gossypium* sp. seeds have been recovered from the excavations. Finds come from occupation phases 7 through to 3 with the largest concentrations in phases 6 and 5 (roughly 2nd – 9th century AD). Whole seeds were recognised as having a pointed ovoid shape, up to 12mm long with a beak and slight ridge (raphe) running from the apex to the base of the seed (fig. 5.10). Frequently fragments of lint were still attached to the apex of the seed. Cotton has a thick seed coat with a layer of distinctive palisade cells lying perpendicular to the seed coat. The seed coat with the palisade cells frequently peel off the charred material leaving the less distinct inner seed. The charred inner seed is often pitted or 'tarry' given the high oil content. In addition to finds of whole seeds, a number of small cap shape pieces were present which were found to derive from the top of the seed immediately below the epidermis, identified as the funicular apex (fig. 5.11). These appear to be quite robust and therefore provide the opportunity to identify cotton when the more fragile seed has been broken.

Two cotton seeds were submitted for AMS dating, producing the following dates:
1600±40 BP (Beta-194241) or 410 to 540AD (95.4% probability)
1770±40 BP (Beta-194240) or 230 to 325AD (95.4% probability).

Both dates therefore confirm the presence of cotton at Jarma from at least the 3rd-4th century AD. The greatest concentration of remains occurs in the period dated stratigraphically between the 2nd and 9th centuries AD. Assuming cotton was being cultivated at the site therefore it would appear to have been a crop of the Garamantian/Roman to Late Antique period. While it is still present in the early Islamic periods the numbers of seeds and its ubiquity decreased (although this may be a product of preservation) and by the late medieval period there is no evidence for cotton at Jarma, although there are ethnographic accounts of its more recent cultivation. Duveyrier records in the early 19th century that both a New World species, *G. vitifolium* (= *G. barbadense*) and *G. herbaceum*, were cultivated, the later, known as 'koton-fezzan', widely so and economically important (Duveyrier 1864, 154). *G. herbaceum* was also recorded in the later 19th century by Nachtigal (1974).

5.2.4.1 Botanical Background

Gossypium is a genus of annual or perennial shrubs or small trees of the tropics and subtropics. The old world cottons, *G. arboreum* (tree cotton), and *G. herbaceum* (short staple cotton) are now cultivated as relic crops only, in parts of India, south-east Asia and Africa (Zohary and Hopf 1994). The New World cottons, *G. hirsutum* and *G. barbadense* produce longer, superior lint and form the greatest proportion of commercially cultivated cottons. It is only the old world cottons which are discussed here. The oldest evidence for domesticated cotton so far comes from Pakistan, although it is yet unknown whether domestication occurred in the Indian sub-continent or Africa or both.

Several reliable finds of textile and strings are now known from Harappan and contemporary (second millennium BC) contexts in India and Pakistan (Vishnu-Mittre 1977; Hutchinson 1976) and it was an important crop in the Indus civilization c.2500-2000 BC (Fuller 1999). Mineralized cotton fibres have been identified from a cotton bead from 6th millennium BC deposits in Mehgahr, central Pakistan (Moulherat *et al.* 2002), while fibres have been radiocarbon dated to c. 4400 cal BC from plaster fragments from the Arabian Peninsula (Betts *et al.* 1994). Further west it is not recorded until the 1st millennium BC when there is a reference that 'trees bearing wool' were introduced into Assyria by Sennacherib in abut 694 BC (Thompson 1949 in Zohary and Hopf 1994). Documentary sources attest to the cultivation of cotton in Hellenistic and Roman period Arabia (Zohary and Hopf 1994) although the extent of cultivation is unclear.

In Africa cotton is first reliably identified in the Nubian Nile Valley. Several finds of Roman or Meroitic Nubian cotton cloth have been reported, from Karanog and Meroë (Crowfoot and Griffiths 1934), Qasr Ibrim (Crowfoot 1977; 1979), and several cemetery sites (Mayer-Thurman and Williams 1979; Bergman 1975). Its history outside this core area has been little understood until recently. Watson (1983, map 4 p. 33, 34-5) argues that until the Islamic period cotton was restricted to very warm regions and suggests these areas were India, Malaya, South China and less extensively Abyssinia (Ethiopia) and Sudan (Watson 1983, 35). He suggests the limiting factor for the spread of cotton had been the lack of a variety adapted to regions with short and colder summers, and short days towards the end of the growing season (Watson 1983, 35). Clearly the occurrence of cotton in pre-Islamic contexts at Jarma suggests its spread in non-Tropical Africa to be earlier. This is supported by a range of new finds of cotton in near contemporary contexts, discussed further in chapter 7.

5.2.4.2 Cultivation and Irrigation Requirements

All the *Gossypium* species are perennial, but annual and biennial forms have been selected for cultivation (Burkill 1994b:20). Annual forms are sown by seed in spring. April to May is given for Syria (International Bank for Reconstruction and Development 1955: 306-8) or late March to the end of April for traditional cotton cultivation on the borders of the Caspian Sea in northern Persia (Guthrie 1798: 218 from Samuel 2001: 381). In the Fazzān a similar period for sowing can be envisaged. Harvest is usually in September of October.

Cotton is a crop of tropical origins which is reflected in its cultivation requirements. Requirements include a frost-free growing season of 200 days or 6½ months (Kochhar 1998; Burkill 1994b:20; Robbins, 1931:497), much sunshine and warm temperatures, and adequate soil moisture during the early stages of growth. Langer and Hill give a figure of the equivalent of 500mm of rain per year (1982:262). Various authors give temperature requirements and/or tolerances of between 21-22°C up to 43°C (Langer and Hill 1982:261; Burkill 1994b:20 and Kochhar 1998:28). The long growing season needs much water in the early stages, followed by a relatively dry season during flowering, and no rainfall during ripening or picking which could cause the fibre to become mouldy or discoloured (Kochhar 1998: 28; Guthrie 1798, 218; Burkill 1994b: 20). This last stage between flower fertilizing and boll opening lasts between 50 and 60 days (Langer and Hill, 1982: 262).

Cotton is also sensitive to salinity during germination (Farnworth, 1997, 301), after which any friable soil with good humus, moisture retention and drainage will do (Kochhar 1998; 28; Klages 1942: 262). Pre-industrial cotton harvest is particularly labour intensive. The bolls must be picked by hand as soon as they open to prevent spoilage. Where this is still the traditional method it is conducted over a period of two months or more as the fruits ripen at different times (Kochhar 1998; 28). The processing of cotton is discussed further in chapter 6.

5.2.5 Fruits and nuts

Perhaps one of the most noticeable elements of the species tables is the long list of fruit species present at Jarma. Date (*Phoenix dactylifera*) is ubiquitous, present in all phases and in almost all samples. Date is most commonly represented by the fruit stone and occasionally whole charred fruit as well as the detached embryos of the stones. The stones themselves are unmistakeable, being large, with a deep furrow down the ventral surface and the round embryo top (or occasionally empty embryo hole) situated in the centre of the dorsal surface. The size and proportion of the stone varied with both short fat and long thin stones present. Occasionally all that remained of the stone was the desiccated wing like, slightly wavy or shrivelled sides of the ventral groove. Charred stones were frequently fragile and shattered easily. Where fragments of stone were encountered they were quantified by estimating whole stones on the basis of stone ends. In addition to the fruit stone, other parts of the date palm were present including the perianth of the fruit, fragments of the strands or rachilla which bear the flowers and later the fruits, and occasionally the desiccated male flower.

The date palm dominates the oasis of Jarma and the vegetation of the floor of the al-Ajāl depression today. The ubiquity and the large number of stones recovered during the excavation were therefore not unexpected. Date palms need a good supply of water to grow so occur in the oases, wadis and beside rivers and are often cultivated under irrigation where they offer shade for crops grown beneath them. Palms are tolerant of hot conditions and saline soils (Bircher, 1995; Goor and Nurock 1968:151) and require little management other than the fertilization of the flowers by brushing the female flowers with flowers taken from male trees, and the removal of suckers from the base of established palms. The local inhabitants in the Wādī al-Ajāl also collect the smaller dates from the base of unmanaged trees. The fruit is the major product of the date palm, which as a food source is eaten fresh or dried and rolled into balls or forced into blocks for storage. The fruit is also used as an animal feed, either whole or as ground stones. High in sugar, dates are an important source of energy and form a major part of the diet in the Fazzān. As such dates would represent a significant exportable product in periods before the availability of cane sugar. It is possible that dates or date pulp were a valuable commodity traded both to the north and to sub-Saharan areas.

The date palm itself is widely used for a range of purposes and represents one of the most valuable resources of the wadi. The trunks and leaves or fronds are used widely for construction, fencing and wind breaks around both domestic plots and arable fields, as well as for baskets, matting, food wrapping, rope making and fuel. In several samples whole dates are burnt in addition to rachilla and perianths and it is assumed that some of these deposits are derived from direct burning as fuel.

Grape (*Vitis vinifera*) and fig (*Ficus carica*), are also numerous in the samples and are recovered from all phases, both charred and desiccated. There is a decrease in grape number and ubiquity in phases 1 and 2. The highly distinctive grape seeds are long and narrow, characteristic of the cultivated fruit (Stummer 1911). In addition to the seeds occasional pedicel (fruit stalks) were also present which have a thickened ruffle at the berry end and warty protrusions. Fragmented seeds were quantified either on the basis of estimating whole seeds or by counting the robust stalk. Fragments of grape seed were only identified if there were visible fragments of stalk or the chalaza on the dorsal side, the two striae on the central side or the saddle shaped base. While it may be possible to identify smaller fragments it was thought unlikely that identification of small fragments would alter final counts significantly. Fig seeds are typically more or less spherical, sometimes laterally compressed with a small beak- like protrusion and usually with a pronounced ridge running along the top of the seed. A round hilum sits just below the beak set into the thickened wall. The actual shape of the seed can be quite variable, but the hilum is very characteristic.

Grape and fig are essentially Mediterranean crops with a long history of cultivation. Grape in particular is not well suited to the environment of the Fazzān being susceptible to dry winds, heat and drought and the leaves are sensitive to scorching and would require careful management. As White states, 'vines require a greater degree of tendance and control of the environment than any other Mediterranean crop' (1970). The vine is dormant in winter and requires high light levels in spring and summer for growth and fruit maturation, but would have needed some shade from the hot sun. While both fruits may have been imported from the Mediterranean region, their ubiquity throughout the phases at Jarma and their presence at Zinkekra (Van der Veen 1992) does suggest them to have been readily available. Grape has been cultivated recently, as attested by vines still present in the wadi (fig. 5.12), and references by early European travellers to the region (Nachtigal 1974; Lyon 1821; Durrand and Baratte 1910). It is possible therefore that the cultivation of both fruits has a long tradition, presumably in irrigated garden plots as today, protected by palm and tamarisk trees. The apparent decrease in grape numbers in phases 1 and 2 at Jarma is interesting given how numerous and ubiquitous it is in earlier samples. Assuming this pattern is not merely a product of preservation, this raises two possibilities: conditions became too harsh for the successful cultivation of grapes in the region (although the relic vineyards provide evidence that it was possible) or that the Islamic prohibition of alcohol resulted in a reduction of viticulture.

Several cucurbits are present in the desiccated samples from the upper deposits (phases 1-3), although always in low numbers. These include watermelon (*Citrullus lanatus*), bitter apple (*Citrullus colocynthis*), cucumber/melon (*Cucumis* sp.), the New World species pumpkin/squash (*Cucurbita* sp) and from the 4mm sieve, seeds of gourd (*Lagenaria* sp.). Occasional charred seeds of gourd, cucumber/melon, watermelon/bitter apple and indeterminate Cucurbitaceae are also present in lower deposits. The greater representation in the later deposits is likely to be largely due to preservation bias.

The most frequently recovered of the cucurbits in the samples are the seeds of melon or cucumber (*Cucumis melo* or *C. sativus*). Both species produce a papery seed which is narrow, flattened and has a typical Cucurbit shaped tapered apical end. The division of the two species is possible in well preserved material on the basis of the attachment scar, being at the flattened apical end in *C. sativus*, while in *Cucumis melo* the flattened attachment point is to one side of the apical end. In practice the seeds, particularly the desiccated seeds, tended to split and curl making positive identification of the attachment scar difficult. One seed of *Cucumis melo* was identified in a phase 1 sample (sample 01S/04, context 061). One charred specimen of *Cucumis melo/sativus* was present in a phase 5 sample while occasional desiccated seeds are present in phases 3 to 1. The melon was brought into cultivation early, by the 2nd millennium BC in Egypt, while the cucumber is of Indian origin and introduced into the Mediterranean region later. Both were cultivated in the Fazzān in the 19th century (Nachtigal, 1879; Duveyrier, 1864). Lyon (1821) mentions that mush melons are only over-ripe cucumbers, demonstrating perhaps that the culinary distinction between the two is negligible.

Desiccated seeds of *Citrullus lanatus* were identified in phase 1 and in phase 4 sample 04I/107 (the possibility that this sample contains more recent material has been raised in chapter 4). Single, indeterminate charred *Citrullus* seeds were recovered from phase 6 and phase 7 samples. Seeds of *C. lanatus* were also recovered in desiccated phase 1 to 3 deposits sieved through 2mm and 4mm sieves. *Citrullus colocynthis* (bitter apple), a wild desert and semi-desert species, widely spread across North Africa and the Near East and common in Libya (Ali and Jafri 1976-), was identified from 2mm and 4mm sieved deposits in phase 1. The watermelon has been in cultivation in the Nile Valley since at least the 2nd millennium BC (Zohary and Hopf 1988) and is today widely cultivated in Libya (Ali and Jafri 1976-). Finds of 5000 year old seeds of a wild form of *C. lanatus* from Ti-n-Torha/Two Cave and Uan Muhuggiag, in South-Western Fazzān, have also raised the possibility of a Saharan domestication for this crop (Wasylikowa 1992, 14; Wasylikowa and Van der Veen 2004). *Citrullus colocynthis* produces round fruits the size of small apples (5-8 cm in diameter) which have an extremely bitter and poisonous pulp, but are widely used for medicinal purposes. The seeds, which are similar in shape to water melon but smaller and with less distinct wings, can be roasted and are eaten as a famine food (Keith 1965; Zohary 1982). Nachtigal refers to the seeds being 'not insignificant in the diet of the poor' in the Fazzān (1974, 117).

The seeds of *Lagenaria* sp. (gourd) are distinctive, flattened with wings, wavy sides, and coloured markings on the front and back. Charred fragments of seeds were recovered from three samples, one each in phases 6, 5 and 3. Desiccated seeds were recovered from 2mm and 4mm sieving of phase 1 and 2 deposits. *Lagenaria siceraria*, (calabash or bottle gourd) was recorded as being used for cups, bowls, bottles etc. by Nachtigal (1879) and is widely cultivated in Libya today including in the Fazzān (Ali and Jafri 1976-; authors own observations).

The remaining fruits are represented by occasional charred seeds only. These include olive (*Olea europea*) in occasional Garamantian deposits (phases 5 – 7 with possible examples in upper deposits), almond (*Prunus amygdalus*) (phases 3, 5 and 6), pomegranate (*Punica granatum*) (phases 6-7, 6 and 5), and occasional fruit stones of Christ's thorn or possible Christ's thorn (*Zizyphus spina-Christi*) (phases 3-7). A peach (*Prunus persica*) stone was also recovered from the 4mm sieving of a phase one deposit. While it is not possible to comment on the distribution of the rarer fruits with any conviction, it is worth noting that there appears to be a slight clustering within the Garamantian period deposits. These rare fruits and nuts seem to appear for the first time in the region in the Garamantian period, being absent from Zinkekra (Van der Veen 1992).

Pomegranate (*Punica granatum*) seeds are extremely variable in form being tightly packed within the fruit. They have one rounded and one more pointed end, and are more or less angular in cross section. A broad groove runs down the seed, which can be very pronounced or quite faint and while present on every seed may be at different locations. No complete seeds were recovered from Jarma. Fragments were identified as pomegranate if the groove was clearly visible (fig. 5.13). The internal surface of pomegranate seed fragments was usually tarry and glossy, distinguishing it from either grape or cotton fragments. Insufficient fragments were identified to enable quantification of whole seeds, therefore fragments have been counted.

Olive, *Olea europea*, was identified on the basis of whole, half or fragments of the stone. While whole or half stone fragments are instantly recognisable by their shape, smaller fragments are difficult to distinguish from *Zizyphus* sp. The internal structure of the stones are different however, and could be distinguished if the raised scar which runs the length of the olive stone was visible. If this scar was absent the ruggose fragments were recorded as *Olea/Zizyphus* sp. Stone fragments were quantified by approximating whole stones.

Almond, *Prunus amygdal*us, produces a stone which is much smoother than other *Prunus* species and has deep pits in the surface and a series of channels visible in cross section. Peach, *Prunus persica* conversely produces a large, deeply ruggose stone with deep furrows but not pits, and which is easily recognizable if complete with a small, thin tapered point at the base and a prominent keel.

Almond, peach, and pomegranate are all best suited to Mediterranean climates, and would require some protection and presumably skill to produce good quality fruit. Almond is fairly tolerant of poor soils and drought but will not produce a good yield in these conditions, while both almond and peach are susceptible to salinity. Pomegranate is of course frequently regarded as an important symbol of fertility. All three fruits were recovered from Roman Tripolitania (Van der Veen, Grant and Barker 1996), although the possibility that peach was a modern contaminant could not be ruled out. There are ethnographic accounts of their cultivation in the region in the 19th century, although Nachtigal suggests it is only the wealthy who attempt to cultivate them (1897, 117). Lyon, travelling in the region in 1818-1829 states that 'pomegranates are fine but not plentiful while peach never comes to maturity' (Lyon 1966).

Whether olive was locally cultivated or not is impossible to say. Nachtigal refers to a rumour of one tree in the Fazzān (1974, 117). It is known to have been a major crop of Roman period Tripolitania (Mattingly 1995), although largely cultivated for oil rather than for the fruit. The presence of the stones in the Fazzān would either indicate its local cultivation or the importation of preserved fruit. The importation of oil to the region is attested by the numerous amphorae recovered from the region (Mattingly 2003; *forth* a).

5.2.6 Condiments

Aromatic herbs were rarely recovered from the samples but occasional seeds were present, particularly in the upper deposits. Black cumin (*Nigella sativa*) seeds have three sides and are minutely papillate. Cumin (*Cuminum cyminum*) produces a long narrow seed with 5 primary ribs and four slight secondary ribs. One desiccated seed was identified from phase 2 sample 02CF/047. Dill (*Anethum graveolens*) produces distinctive seeds with a flat ventral surface, gently rounded dorsal surface and 5 distinct ridges, the two outer ridges forming slight wings. In the charred specimens the outer ridges are distinct while the three dorsal ridges are prominent. One charred specimen was recorded in a phase 3 sample. A possible seed of fennel (*Foeniculum vulgare*) was recorded in the same sample. The seed is elongate, broken but over 3mm in length, with acute ends and five strong rounded ridges. Coriander (*Coriandrum sativum*) produces a very distinctive fruit which is spherical and with wavy primary ridges. Two charred specimens were tentatively identified in phase 6 and phase 5. In both cases the mericarp has been flattened although is still slightly curved, and the primary ridges are indistinct. However the roundness of the mericarp is suggestive of coriander. This flattening of the seed has been noticed in charred material by Samuel (2001) and it appears that is the result of charring. Seeds of wild celery (*Apium graveolens*) were identified from charred remains. The fruit is broadly ovoid or sub-globose, 1.5-2x1-1.5mm with 5 prominent ribs. The charred specimens are small, c. 1mm in length. Seven charred seeds were identified from phases 6 to 4. While this is a common weed of arable or waste places, it is also cultivated for its leaves and roots. Finally one poorly preserved charred specimen from sample 06F/513 was tentatively identified as cf. *Papaver somniferous* L. (opium poppy). The seed is comma shaped with some traces of the large cell structure. Opium poppy is commonly cultivated for its seed for culinary purposes, its use for bread apparently dating from the Roman period, as well as for opium which is produced from the latex released after gashing the unripe capsules.

All of these aromatic herbs have a long ancestry, known from either the prehistoric Near East or dynastic Egypt (Zohary and Hopf 1994). As with many condiments their use became widespread during the Roman period. Such herbs could have been cultivated all year round in watered garden plots. In addition to use as culinary herbs the Apiaceae in particular have medicinal uses, particularly as a carminative. The root, leaf and fruits of wild celery for example are used in folk medicine as a diuretic, aphrodisiac, carminative and tonic, while the fruit is said to relieve lumbago and rheumatism (Ali and Jafri 1976 -, vol. 117). Fennel is widely used to aid digestion.

5.2.7 Possible oil crops

Olive is not believed to have cultivated in the Fazzān as an oil crop, but rather is likely to have represented a fruit while the oil was imported from Tripolitania or Tunisia. Two possible oil crops are likely to have been locally cultivated: linseed or flax (*Linum usitatissimum*) and Sesame (*Sesamum indicum*). Both plants produce a valuable oily seed which could be pressed or used whole.

Both seeds and capsule fragments of flax are represented, particularly in the phase 1 to 3 desiccated samples. The preservation of the seed was generally poor but identification was possible on the basis of the general shape, being flattened with a hooked apical end, and surface structure which has a distinctive cell pattern under higher magnification. Capsule fragments are spongy in texture, individual sections of capsule are pointed at either end and gently curved. The presence of mature capsule fragments suggests that the remains have derived from the extraction of seeds, and not for the production of fibre. Nachtigal (1974) records that flax was cultivated in small quantities in the Fazzān as only the seed was wanted, used medicinally or for oil.

The identification of sesame (*Sesamum indicum*) is tentatively based on two seeds (fig. 5.14). *Sesamum indicum* is of the family Pedaliaceae. The archaeological seeds are flattened, broadly elliptical, with the widest point in the lower half and with a slight point at both the narrow and wide end. The seed coat (hull) is absent and the endosperm is exposed. The seeds are much smaller than modern cultivated sesame and cultivated varieties do not have the lower point, therefore a wild species might be represented, possibly *Pedalium murex*. The sizes are 1.6x0.6x0.4mm and 1.8x0.8x0.5mm. The preservation of charred sesame seeds tends to be poor given the high oil content of the seeds, as has been noted by Samuel (2001), consequently archaeological specimens are rarely recorded. Sesame is a traditional warm season crop in south-west Asia and the Mediterranean basin (Zohary and Hopf 1994). It was extensively cultivated in the Greco-Roman world apparently for its seeds rather than its oil (Lenz 1859; Gallant 1985 in Zohary and Hopf 1994). Its origins are believed to be tropical, from India, not reaching the Near East until relatively late. The oldest archaeological records to date are from Harappan deposits in the Indus Valley some time between 2250 and 1750 uncal bc (Bedidian 1985).

5.2.8 The New World Crops

New World crops are represented in the upper deposits of the site, principally phases 1 and 2, with occasional finds in phase 3. Finds in earlier phases are regarded as intrusive. They are represented in the samples by seeds of pumpkin (*Cucurbita maxima*) or summer squash (*Cucurbita pepo*) and several desiccated seeds tentatively identified as chilli/sweet pepper (*Capsicum* sp.). *Cucurbita* spp. seed coats are typically Cucurbitaceae in shape, with slight wings at the apical end. They are spongy in texture compared to other genera. *Capsicum* seeds are rounded, with a pitted surface rather than clear cellular structure and have a clear beak at the attachment point which does not appear to be present in other Solonaceae genera. In addition to the above sample finds, finds of maize (*Zea mays*), actually represented by chewed cob fragments (both charred and desiccated), were recovered from phase 1 deposits by 4mm sieving and hand collection during the excavation. Two cob fragments were AMS dated, from contexts 082 and 065, giving recent uncalibrated dates of 161±35 BP and 95 ±37BP.

While maize requires much water when first sown it will tolerate dry conditions once established, producing high yields even in small plots and on rather depleted soils. Maize was probably introduced to the Mediterranean region by the Portuguese and was established along the North African littoral by the end of the 17^{th} century (Blench *et al.* 1994). From North Africa maize seems to have moved south and west along Trans-Saharan trade routes. According to Pasch (1983, f.211, map 2) it was brought to the Lake Chad region from Tripoli and from further east. It was certainly being cultivated in the

Fazzān by the late 19th century (Nachtigal 1974), although Lyon (1821) makes no mention of it in the early part of the century.

5.3 The Weed and Wild Taxa

A range of weed or wild taxa were present in the samples from Jarma which are described by family. Where possible ecological data and growth habit were obtained from the *Flora of Libya* (Ali and Jafri 1976 -). In the absence of relevant information in the *Flora of Libya* a range of alternative floras have been consulted including *Flore et vegetations du Sahara* (Ozenda 2004). Seeds or other items which have not been identified but were sufficiently well preserved to be distinguishable are described and given codes.

Aizoaceae

Aizoon cf. *hispanicum* L.

The archaeological material consisted of small seeds (0.7 – 1mm diameter) which are rounded-reniform, beaked, slightly compressed and concentrically ridged. The *Flora of Libya* (Ali and Jafri 1976 -) gives, two species, *A. hispanicum*, a species of sandy stony ground found throughout Libya and *A. canariensis* reported as an exotic and cultivated in West and South-West Libya (Fazzān, Tripolitania). The archaeological material is thought to be *A. hispanicum* given *A. canariensis* is regarded as an exotic. *A. hispanicum* is a low growing (up to 30cm) spring flowering species characteristic of stony desert habitats. It is occasionally present from phase 6 onwards as charred remains (6 seeds in total).

Amaranthaceae

Amaranthus cf. *augustifolius* Lam (=*A. graecizans* L., *A. sylvestris*), is the only *Amaranthus* species given in *Flore du Sahara* (Ozenda 2004). The seed is circular, compressed and shiny with a slight keel at the margin, 1mm in diameter. Up to 70cm tall, it is a common arable weed or weed of waste places, especially in sandy soils and desert environments, found across Mediterranean and tropical Africa. It flowers in spring and summer. Charred seeds are present from phase 7 onwards while one desiccated seed was identified in phase 3. Phase 3 sample 03PF/105, produced seven seeds of *A. augustifolius* and two of possible *Amaranthus* sp., as well as 31 poorly preserved seeds recorded as Amaranthaceae/Chenopodiaceae which often lacked the shiny outer seed coat. It is thought likely that these seeds are poorly preserved *A. augustifolius* given the absence of any positively identified Chenopodiaceae in the deposit.

Apiaceae

A range of seeds of Apiaceae were present, including possible aromatic herbs. Most examples were poorly preserved and were recorded as large or small seeded Apiaceae. One species which has not been identified is clearly distinguishable and given the code Apiaceae Jarma A. Possible cumin, dill and coriander are discussed above under 'condiments'.

'Apiaceae Jarma A'. This type consisted of small ovoid to oblong seeds, 0.8-1.1x0.5-0.6x0.6mm (fig 5.15). The ventral groove runs most of the length of the seed. The surface is covered with faint tubercles with slight ridges where the epidermis has burnt away. A total of 79 seeds were present from phases 5 to 3. A large deposit of 55 seeds was present in hearth sample 04I/128.

Asteraceae (Compositae)

Poorly preserved Asteraceae were recorded as large or small seeded.

Calendula sp. This genus was recognisable by its distinctive, curved, spiny cypselas. In all examples the cypsela was damaged or insufficiently distinct to allow identification to species, particularly given the variation witnessed in fresh material. The *Flora of Libya* gives three species: *C. arvensis* L. (= *C. aegyptiaca*), a Mediterranean species widely distributed and a common arable weed, *C. tripterocarpa* Rupr., of western Mediterranean origin and a common arable weed, and the ornamental species *C. officinalis* L.. All three species are winter and spring flowering and of medium height (40 – 70cm).

Boraginaceae

Heliotropium cf. *europaeum* L. Nutlets were glabrous, highly rugose with a curved back and measured 1.5-1.8mm. They were rare in the samples, with 5 charred seeds in phases 7 and 6 and 1 desiccated in phases 1-2. The species occurs as an arable weed, but also as a roadside weed or near buildings.

'Boraginaceae A' (fig. 5.16). Nutlets were small and hard (1.5mm in length), beaked and tuberculate with a narrow and a broad ventral keel. A total of 17 nutlets were present in samples from phase 10 onwards. The nutlets are similar to *Buglossoides* species although positive identification was not possible.

'Boraginaceae B' (fig. 5.17). A large and broad, hard nutlet (2.7 x 2.0 x 1.7mm), with a beak, curved dorsal surface, strongly keeled ventral surface, prominent shoulders and fairly smooth surface. One specimen was present in phase 5.

'Boraginaceae C' (fig. 5.18). One charred nutlet was identified from a Phase 6 sample, measuring 1.8 x 1.0 x 1.0 mm. The nutlet had a smooth (although damaged) surface, and was dorsally convex with a wide collar at the base, only a slight ventral keel and no obvious shoulders.

Brassicaceae (Cruciferae)

One poorly preserved charred and one desiccated seed were identified as Brassicaceae indet. Both were small (<1mm).

'Cruciferae V' (fig. 5.19) This type was represented by capsules, which were woody/fleshy, in one seeded segments, circular in cross section, with a smooth rounded top, forked base and ribbed sides. The capsules were particularly numerous in sample 07CF/549 (79 charred specimens), and occasional charred capsules were present throughout.

Coronopus sp. This genus was represented by pairs of almost spherical fruits with a strong central keel where the seeds join. The fruit measures 2.0 x 2.2 x 2.0mm, and is glabrous, strongly reticulated, with no obvious beak and a strong ventral keel. They are similar to *Coronopus squamatus*, but much rounder and plumper than the reference material, possibly being more mature. They do not compare well with *C. nilotica*. They are represented by two charred seeds in a phase 1 sample 01S/022 and single desiccated examples in 04PF/107 and 01S/003. *Coronopus squamatus* is the only species recorded for Libya (Ali and Jafri 1976-), a herbaceous plant of moist ground, the leaves are eaten as a green salad and roots are cooked and eaten (Boulos and el-Hadidi 1989).

cf. *Raphanus raphanistrum* L. (wild radish). One fragment of desiccated capsule from sample 1/2S/048 was tentatively identified as *Raphanus raphanistrum*. The capsule fragment consisted of a piece of thick, spongy exocarp (measuring 2x1.5mm) with one ridge. The internal surface was slightly shiny, while the surface texture was insufficiently clear to positively identify the characteristic mesh structure (Smith, 1999). This is a common and widespread weed of cultivated land, sometimes cultivated for fodder (Ali and Jafri 1976-).

Caryophyllaceae

Poorly preserved examples were identified to family only. This is a large family of which many genera are common weeds of arable or waste places.

Silene gallica L. Three charred specimens were identified (phases 8 and 3). Twelve desiccated seeds were identified including 8 from hearth sample 04I/128. The seed is rounded-reniform, 1mm long, faces deeply concave and striate, back wide, shallowly grooved. This species is a common weed of cultivated fields and gardens as well as of waste places, winter/spring flowering.

Chenopodiaceae

'Chenopodiaceae A'. The seeds are 1.3mm diameter, ovate, finely spirally reticulated to smooth with a slight beak, spiral embryo and are laterally compressed. Examples were present in one sample only (07CF/549), where 25 charred seeds were identified. This sample also produced a number of utricles of *Cornulaca monacantha*, the fragments of seeds of which are still visible appear similar. It is likely that these seeds are the same species.

Chenopodium murale L. Circular seeds, 0.8-1mm, laterally flattened, lenticular, acutely keeled at margin and minutely pitted. Erect, spring flowering (Feb-May) herb, up to 70cm. This is a widespread weed of waste places which is also used as a salad. Six charred seeds were identified from phase 8 onwards. Occasional *Chenopodium* sp. seeds are possibly also of this species. Two desiccated seeds were present in a phase 3 sample.

Cornulaca monacantha Del. This species was identified on the basis of its woody utricles (fig 5.20), which are laterally compressed, the seeds held vertically within, and 3.4-4mm in length. The seeds may also be present in sample (07CF/549). This is a small desert shrub, up to 60cm tall, which in Libya is confined to the southern desert regions. The shrub is eaten by camel. Charred examples were occasionally present from phase 7 onwards, while they were numerous in sample 07CF/549. The utricles were identified by Alan Clapham, and also agree with a photograph provided by Wendy Smith of archaeological material from Kom el Nana, Egypt (Smith 2003).

Suaeda sp. The archaeological material consisted of an ovoid-subreniform, shiny seed, 1mm diameter with a slight beak. The Flora of Libya gives 6 species, of which four are beaked: *Suaeda monodiana*, *S. vera*, *S. pruinosa* and *S. palestina*. These are low shrubs of sandy and saline conditions, mostly with a predominantly coast distribution. *S. monodiana* is endemic to Mid- and Western Saharan, a desert species now confined to, but common in, the Ghat area in Libya and probably eaten by camel (Ali and Jafri 1976-). One desiccated seed was identified from sample 01S/003, while occasional charred seeds were present from phase 7 onwards.

'Chenopodiaceae/Amaranthaceae'. Several poorly preserved seeds could not be distinguished as Chenopodiaceae or Amaranthaceae. Where large numbers of these seeds occur their genus can be surmised by association with well preserved specimens. In sample 07CF/549, 50 seeds recorded as Chenopodiaceae/Amaranthaceae are present with 25 Chenopodiaceae A (cf. *Cornulaca monacantha*, see above) and no other likely genus.

Sample 03PF/105 produced 37 poorly preserved seeds with 8 well preserved seeds of *Amaranthus* sp. Elsewhere they occur in low numbers and no obvious association can be made.

Cyperaceae

The achenes of at least two species of Cyperaceae were occasionally identified, with less well preserved examples also occasionally present, both charred and desiccated.

Cladium mariscus (L.) R. Br. The achene is ovate or ovate-lanceolate, tending to globular with a distinct beak. This is a tall perennial species, widespread near water, near wadis, ditches, springs and marshes. Occasional charred examples were present from phase 5 to 3 and slightly more numerous desiccated achenes were present in the upper levels.

'Cyperaceae A'. Biconvex and obovate achenes, c.1mm x 1mm, preserved as silica skeletons, were occasionally present in phases 5 to 3.

Euphorbiaceae

Occasional small seeded *Euphorbia* sp. (up to 1.5mm) were present but lacked characteristic features for identification, tending to be smooth and globular. Two species were identified.

Euphorbia helioscopia L. The species produces a distinctive globular seed, 1.5x1.8x1.2mm, reticulately rugose with a transversely ovate or semi-orbicular caruncle. The plant is a widely distributed species in cooler areas of Libya, occurring as an arable weed of medium height (50cm), flowering in winter/spring (Jan/April). Charred seeds were occasionally present from phase 7 onwards.

Euphorbia peplus L. This species produces small seeds, (1.2-1.4x0.8), ovoid-hexagonal in cross section, sulcate ventrally and pitted dorsally. A common and widespread winter weed (flowering Jan – May) of fields and waste places, fairly low growing (up to 30cm). Charred seeds were present from phase 6 (rare) and more frequently from phase 5. Desiccated seeds were present in phases 3 to 1.

Fabaceae (Leguminosae)

Alhagi sp. (camel thorn). Segments of pod were present in several samples with seed visible or falling loose in several examples (fig. 5.21). Pod segments are 3 to 4.5mm long, usually containing 1 to 2 seeds, with a slight beak at constriction points between segments where pods tended to break. The seed pod coat is thick and spongy. Seeds are oblong to sub-spherical, frequently laterally compressed and shrivelled as if immature. Seeds were of variable size ((1.5) – 2 – 2.5mm in length). Seeds were identified to genus when found enclosed in pod fragments. Pod and seeds are present as charred material from phase 5 upwards, but are particularly numerous in phase 3. Desiccated pod fragments are particularly common in sample 04PF/107 and charred fragments in sample 03PF/105. Both samples also contain numerous indeterminate Fabaceae seeds which could not be identified to genus but which compare well to *Alhagi* sp. seeds. The *Flora of Libya* (Ali and Jafri 1976-) gives one species, *Alhagi graecorum* Boiss, an armed shrubby perennial up to 1m in height, characteristic of sandy ground and desert. Examples were not available in UCL reference material. *A. maurorum* Medik. was available in the reference collection and compares well, although archaeological material is slightly smaller. *A. maurorum* is reported to be present in Libya but unconfirmed in *Flora of Libya*. Both are regarded as the same species by Boulos & el- Hadidi (1989), who state that the plant is grazed by camels and goats, dry plants used as a laxative, vermifuge, for rheumatic pains and bilharziasis.

cf. *Onobrychis* sp. (Sainform, holy grass, French grass). This genus produces a distinctive seed pod. The charred specimens were worn but quite clear (fig. 5.22), and are 4.5 -5mm long, compressed, and the surface covered in distinctly raised network of veins. The charred specimens lack the raised teeth on fresh pods of some species. The *Flora of Libya* gives two species of which *Onobrychis crista-galli* (L.) Lam is similar but larger with teeth. The other species, *O.caput-galli,* does not compare well. The pods do compare well with *O. viciifolia* Scop. (*O. sativa* Lam.) which lacks the distinct teeth seen on other species. *O. viciifolia* is a perennial fodder crop in Mediterranean environments and traditionally in chalk-lands of Britain (Robinson 1947). Two charred seed pods were identified in sample 07CF/549.

cf. *Onobrychis* sp. small pods. Two small pods of similar character to the above were recovered from the same sample. They were smaller (1.6 x 2.5mm), with fewer cells and a triangular cross section. They compare quite well with *Onobrychis halysensis*, another fodder crop and a common contaminant of *O. viciifolia* (Robinson 1949).

Vicia/Lathyrus sp. Spherical seeds lacking testa or hila. Small seeds distinguished from intermediate on the basis of size, where small seeds were smaller than 2mm, indeterminate were between 2 and 2.5mm. They were rare in the samples, represented by 7 charred seeds only.

Fabaceae indet. These seeds consisted of *Alhagi/Trifolium/Lotus* sp. type shaped seeds but of varying degrees of preservation. The seeds were insufficiently distinct to allow identification without pods. They were distinguished as small or indeterminate on the basis of size (small being <2mm, indeterminate 2 – 2.5mm). Seeds were numerous in some samples, for example in sample 07CF/549 and 03PF/105 which also contained large numbers of *Alhagi* sp. They were present in low numbers throughout the deposits. This group probably represent a range of species including possible fodder crops.

Fumariaceae

Fumaria sp. Seeds were spherical with a slight keel, 2mm diameter. Species of this genus occur as weeds of fields, gardens, orchards and of waste ground, of Mediterranean, European and Western Asian origin. Rare charred seeds were present in phases 7 to 5, desiccated seeds in phases 4 to 1 with a large deposit of 21 seeds in sample 04PF/107.

Liliaceae

Asphodelus tenuifolius Cav./*fistulosus* L. Seeds were sectoid, triangular to sector-shaped in cross section with sharp edges, with two flat faces each with 2 to 3 or more dents or cavities on each. The back side of the seed is convex with c.4 transverse dents or cavities.

Sizes ranged from 2-2.5x1-1.5x1-1.2mm. Nine desiccated seeds were identified including 8 from sample 04PF/107. A total of 17 charred seeds were identified from phase 6 onwards in low numbers, with 11 seeds in sample 04I/128. The *Flora of Libya* (Ali and Jafri 1976-) gives five species of which *A. tenuifolius* and *A. fistulosus* compare well. *Flore et vegetation du Sahara* (Ozenda 2004) gives two species, *A. refractus* which does not have the cavities or dents and *A. tenuifolius*. *Asphodelus fistulosus* is an arable weed which in Egypt occurs only in the Dakhla-Kharga association and is absent in the Nile region (Kosinova 1975 in Boulos & Hadidi 1989). *A. tenuifolius* is a tall desert weed (1 - 1.5m tall), commonly occurring in desert regions and sandy places, widespread in Libya. Both species are spring flowering.

Malvaceae

Malva sp. A variable genus of which there are 5 species recorded for Libya, of which *M. verticillata* is a native of China (Ali and Jafri 1976-). Seeds were rare in the Jarma samples consisting of one charred and one desiccated seed. Both seeds are smooth, with two flat faces and a rounded back.

Plantaginaceae

Plantago sp. The seed is cymbiform (boat shaped), oblong, elliptic, 2.2x2.5x1-1.2mm. The *Flora of Libya* (Ali and Jafri 1976-) gives 16 species of which seven are possible. *Plantago ovata*, *P. afra*, and *P. arenaria* are used as cures for dysentery. *P. lanceolata* is of variable habitat and habit, *P. albicans*, *P. notata* and *P. squarrosa* are common in dry, sandy or stony places.

Poaceae (Gramineae)

The grasses form the biggest group of weeds or wild taxa in the Jarma samples. Several of the taxa present may represent cultivated or at least exploited species, particularly for animal fodder. The identification of Poaceae caryopsis is extremely difficult for many genera, particularly the small 'millets'. Identification of grasses therefore follows Nesbitt (2006) and Fuller (2006; unpubl) with reference to descriptions and illustrations in a range of papers from African archaeobotanical sites. The identification of several taxa is tentative, or to 'type' only.

Bromus sect *Bromus*. Long narrow dorsally compressed caryopses up to 6.5mm, with a short embryo, V-shaped scutellum and long linear hilum. Nesbitt divides *Bromus* into short group, section *Bromus* and *B. tectorum* where caryopsis is 4.9 to 9.5mm and long group, section Genea where caryopses are longer than 10.6mm (Nesbit 2006). Around 12 species are recorded in Libya, of which 6 are of sect. *Bromus*. Generally *Bromus* species are regarded as weeds of disturbed ground and arable fields, commonly retained with harvested wheat and barley grain given the similar size of the caryopses. Charred grains were occasionally identified in samples from phases 5, 6 and 7.

Dactyloctenium aegyptium (L.) Beauc. This species produces very characteristic caryopses, triangular in shape with truncated ends from lateral view. The surface is strongly sculptured by wavy ridges. This is the only species recorded in Libya and highly distinctive. It is a common annual weed of sandy soils in shady and moist places during warm months. The grass has little fodder value, although the seeds have some medicinal uses for treatment of inflammation of the kidneys and nervous disorders, and the roots for amenorrhoea (Ali and Jafri 1976-). It is not considered a potential cultivated crop but it is gathered as a food grain by Saharan nomads as well as being suitable for hay and silage (BOSTID, 1996, 267). One charred caryopses was identified in sample 04I/128

Digitaria B Charred caryopses are obovate with narrowed to acute apex, flat ventral and dorsal surfaces (fig. 5.23). The scutellum is 1/3-1/2 length of seed and wide, the hilum is short and rounded and the embryo flat to slightly convex and shallow. Length:breadth index is c. 1.5. One specimen has the lemma still attached which is smooth with a pointed distal end. A total of 15 caryopses present in two phase 7 samples (07CF/549 and 07S/592)

Digitaria sp. type. The scutellum is just under half the length of the caryopsis. The caryopsis is narrow-obovate with a narrowed to acute apex. They are similar to examples described and illustrated from Kursakata (Zach & Klee 2003). One caryopsis was present in each of sample 03PF/106 and 05S/410. Desiccated glumes were present in one phase 6 sample.

Eleusine cf. indica (L.) Gartn. The species produces a distinctive sculptured caryopsis, some what triangular in shape, laterally flattened with a trigonal cross-section and truncate apex. It has a wide ventral groove running from shortly above the hilum to the apical end. The hilum is circular and the scutellum short and triangular on an acute angle to the dorsal surface. Six to ten ridges run over the lateral sides to the ventral groove. Four charred caryopsis were identified in sample 03PF/106. *E. indica* is a summer weed of arable crops and an important summer forage grass. *Flora of Libya* also lists *E. compressa*, a species of warmer arid or sandy areas, recorded in the Tibesti and *E. coracana*, finger millet, a Tropical species, sometimes cultivated as a fodder plant in southern Libya.

Cynodon sp. Identified on the basis of small oval, laterally compressed caryopses with a sharp dorsal ridge and a sub-basal oval hilum (fig. 5.24). The scutellum reaches almost to half the length of the caryopsis and reaches an acute end. The caryopsis length was 1 – 1.2mm. Charred and desiccated caryopses were occasionally present in samples from phase 5 onwards. A large deposit of 62 charred caryopsis was present in sample 03PF/105 including some within a matrix of organic matter (dung?) suggesting its use as fodder. The *Flora of Libya* gives one species, *Cynodon dactylon*, a common summer flowering (July to October) perennial grass growing near water, and mostly used for lawns and fodder.

Cynodon B type. Similar to the above, with embryo c. ½ length of caryopsis, caryopsis laterally flattened, round sub-basal hilum. It is separated from *Cynodon* sp. on the basis of size, maximum measurements being 1.0 x 0.6 x 0.3 mm. The type is identified from occasional phase 1-2 desiccated caryopses and lemmas and rare charred caryopsis in phase 5 onwards, with 15 caryopses in sample 03PF/106.

Hordeum sp. Charred caryopses were broadly rectangular in shape, with fairly straight sides and were dorsally compressed, have a short embryo and long linear, shallow hilum. The grain length was 2.7 – 3mm. A total of 32 charred caryopses were present from phase 7 onwards. A deposit of 15 caryopses was present in sample 04I/128 which also contained rachis of cultivated *Hordeum vulgare*. Wild types possibly include some immature cultivated grain, although wild *Hordeum* is possibly present as a weed of the cultivated crop. Five wild species are present in Libya (Ali and Jafri 1976-), all common arable weeds.

Lolium/Festuca type. The caryopses of this type were dorsally compressed, with a short embryo, long linear hilum and V-shaped palea groves on the ventral surface. Given the limited number of grains present and the variable preservation as well as variable grain morphology within the various species, identification to species or type was only attempted for a very few well preserved grains. *Lolium* type grain were distinguished from the smaller *Lolium/Festuca* sp. on the basis of size. Several of the species hybridize and they are common weeds of arable fields, easily harvested with the wheat or barley grain given their similar size. They are susceptible to fungal disease, which is poisonous to grazing animals and humans. This is particularly well documented in *Lolium temulentum*, known as a contaminant of flour since ancient times which can lead to the poisoning of humans (Nesbitt 2006).

Festuca pratensis group. The caryopses of this group were rectangular, dorsally compressed with a short embryo, long linear hilum, V-shaped palea groves on the ventral surface and with a horse-shoe shaped grove on the dorsal surface around the edges. The grain size (length x breadth) is 3x1.5mm. One species is recorded for Libya, *Festuca arundinacea* (section Bovinae), a pasture grass, c. 1m tall, erect and tufted, which flowers in late spring/early summer. This species is thought to hybridize with *Lolium perenne* and *L. multiflorum* (Ali and Jafri 1976-) with which it is closely related. The caryopsis are also similar to *Lolium multiflorum* or *L. rigidum* and may therefore be confused, although the small size is more characteristic of *Festuca* sp. Four charred grains were present in sample 03PF/105.

Lolium temulentum. The grain of this species were rounded in cross section, straight sided, much thicker than other Lolium species and with a short embryo. One desiccated caryopsis was identified in sample 1/2S/048 with a large deposit of *Pennisetum glaucum* chaff. The grain can be toxic and potentially fatal to livestock, a fact known since Greco-Roman and Pharonic times in Egypt, although young plants are used for fodder either alone or mixed with other grasses (Boulous & el-Hadidi 1989).

Paniceae indet. A large number of caryopsis clearly identifiable as Paniceae were left unidentified. They typically displayed a broad oval outline, and were variously dorsally compressed (rather than laterally). The dorsal surfaces tended to be convex while the ventral surface was flattened. The scutellum reaches approximately half the length of the grain and hilum where present was small and horse-shoe shaped. Small and large grains are distinguished.

Panicum cf. *turgidum* Forsk. The caryopses of this species are elliptical with the widest part in the centre, have an acute apex and a rounded scutellum apex. They are dorsally compressed but less so that *Panicum* cf. *repens*, and have a convex ventral surface. The scutellum is about ½ length of caryopsis. This is a rare species in the samples, four grains present in phase 5. The grass is widely distributed in Libya, particularly in wadi beds and its paucity in the samples is possibly surprising. It is a good forage grass during the spring sowing season, recommended for dry land pasture and extensively grazed by camels and other animals. The grain was formerly harvested in large amounts in parts of the Sahara (BOSTID, 1996, 261).

Panicum cf. *repens* (fig. 5.25). Caryopses are elliptical and elongate, dorsally compressed, with an acute apex, and slightly rounded scutellum apex. The caryopsis length is 1 to 1.3mm, mostly 1.2mm. The scutellum is about ½ length of caryopsis and the embryo shallow, while the hilum is narrow and oval. Fragments of palea show transverse wrinkles. Charred caryopses are particularly common in the samples, with 108 grain altogether from phase 8 onwards. There are two larger deposits: 53 grain in sample

05S/410 and 23 grain in sample 03RF/108. They compare well with *Panicum repens* in the UCL reference material. The *Flora of Libya* (Ali and Jafri 1976-) gives three species of *Panicum*, *P. turgidum* (see above), *P. miliaceum* which is much larger and broader, and *P. repens.* This last species is not common in Libya but is a good summer flowering forage grass. It is a weed of fields, ditches, gardens and canal banks in Egypt (Boulos and el-Hadidi 1989). *Flore et vegetation du Sahara* (Ozenda 2004) lists *P. turgidum* and *P. repens*. Some 50 *Panicum* species are recorded for West Africa including domesticated species and species for which the grain is collected for human food, while many provide useful fodder (Burkhill 1994). *P. repens* is said to produce a good fodder with a higher than average nutritive value, although it can become a pernicious weed of cultivated groups, difficult to eradicate (Burkhill 1994, 304). It grows in the proximity of water (*ibid.*).

Phalaris sp. Caryopses were narrow, oval and laterally compressed, with sharp dorsal ridge and convex ventral surface, with acute apex and scutellum apex. The embryo is ⅓–½ length of the caryopsis. The length of the caryopsis is 1.7 – 2.0mm. They are fairly common in the samples with 95 charred grains in total from phase 9 to 3 and 50 desiccated grain in phases 5 to 1. The *Flora of Libya* gives 7 species, of which *P. minor* and *P. canariensis* are cultivated as an ornamental and as a forage grass (Ali and Jafri 1976-).

Polypogon sp. Small oval caryopsis, with scutellum less than half the grain length, rounded cross-section, sub-basal oval hilum within a shallow ventral groove, c. 0.8mm in length. *Flora of Libya* gives three species, *Polypogon monspeliensis*, *P. maritimus* and *P. semiverticillatus* (Ali and Jafri 1976-). *P. monspeliensis* is characteristic of moist ground around wells or irrigation canals in Egypt (Boulos and el-Hadidi 1989). A total of 8 charred caryopses in phases 7 to 5 were identified.

Setaria/Brachiaria/Echinochloa species have scutellum length markedly longer than ½, usually exceeding ⅔ caryopsis length (fig. 5.26). *Echinochloa* tends to be more rounded with a blunt apex, where apex is more acute grain can be distinguished as *Setaria/Brachiaria* sp.

Setaria verticillata type (fig. 5.27) Oval caryopses, 1.5 – 1.7mm in length, with the widest point slightly lower than the middle, although less rounded and narrower than *Brachiaria* or *Echinochloa* species. The apex of the scutellum is rounded, while the sides are parallel. Has a sub-basal oval hilum. The palea sculpturing has pusticulae arranged in longitudinal rows, distinguishing it from *S. pumila*. This was faintly visible in the archaeological material but not conclusively clear. Six caryopses were identified between phases 7 and 3. *S. verticillata* is an annual tufted grass up to 1m high. It is a ruderal weed of waste and cultivated places often in damp and shady sites including irrigation channels (Boulos and el-Hadidi 1989; Burkhill 1994) and makes a good fodder as hay (Burkhill 1994).

Brachiaria ramosa/deflexa type Caryopsis are ellipsoidal, with maximum width near the centre, rounder than in *Setaria* spp., with an obovate hilum, longer than in *Setaria* spp., and a scutellum which is wider than in *Setaria* spp. Charred caryopsis were present in all phases, with 65 in total. Usually present in small numbers with one larger deposit of 17 caryopses in sample 04I/128.

cf. *Paspalidium* sp. Small oval caryopsis, 1.4 x 1.0 x 0.5mm, with a short embryo and short rounded hilum, dorsally flattened, slightly ridged or rugose. One caryopsis was present in sample 04I/128. One species is recorded in Libya, *Paspalidium geminatum*, a summer grass of highly moist habitats (Ali and Jafri 1976-). This is the only species listed in Burkhill (1994), for which it is described as growing on wet sand banks, sites of temporary inundation, marshes and in water to 2m deep, sometimes brackish. It is found in irrigation channels in Ethiopia (*ibid.*).

'Poaceae 4' Caryopsis are elongate (1.3mm long) and narrow, with small embryo, linear hilum reaching just short of the apex, acute apex and round cross section. Three charred caryopses were identified in phase 5 and 6.

'Poaceae N' (fig. 5.28). Caryopses are oval in plan and angular in cross section, with parallel sides, flattened dorsal surface and slightly convex ventral surface, a short fan shaped scutellum, rounded to slightly acute apex, slight dorsal ridge and linear hilum running almost full length of the caryopsis. Caryopsis length measures 1.9mm. One charred caryopsis in phase 1.

'Poaceae O' (fig. 5.29) This type had an elongate and narrow caryopses (length 2.6mm) with a small oval embryo, sub-basal oval hilum and rounded cross-section. A total of 7 charred caryopses were present in sample from phase 7 to phase 4.

'Poaceae R' This type has a narrow, elongate caryopses (2.6 – 3mm length), rounded in cross section, with a small oval scutellum and sub-basal short linear hilum. A total of 10 caryopses were present from phase 7 to phase 4 (fig. 5.30).

'Poaceae Z' Caryopsis oval, rounded apex and scutellum apex, rounded profile with slightly angular underside, broad linear hilum, rounded scutellum c.1/3 length of caryopsis. 2mm in length. Possibly a puffed up *Hordeum* grain. One charred caryopsis in sample 03PF/106.

Polygonaceae

Emex spinosus L. Identified on the basis of its distinctive spiny perianth which encloses trigonus nuts. One desiccated nut and perianth were present in sample 04PF/107. The species is a weed of arable and cultivated land, and of waste places.

Portulacaceae

Portulaca oleracea L. Identified on the basis of its seeds which are globose-reniform, verrucose-granulata, variably compressed, and c.1mm diameter. The species is a spring and summer flowering, low growing, succulent annual herb, with a prostrate to erect habit which occurs as a weed of gardens and cultivated fields in Libya (Ali and Jafri 1976-). It is particularly characteristic of irrigation channels (own observation, M. Robinson *pers. comm.*). Some varieties are grown as a vegetable or pot herb. This is the most abundant weed found in the Jarma material with a total of 913 desiccated and 82 charred seeds. It occurs in large numbers in individual samples, for example 584 desiccated seeds in sample 04PF/107 including seeds incorporated in sheep/goat dung, and 59 charred seeds present in 03PF/105. However, it is absent prior to phase 4. It is presumably present either as a fodder plant or has entered the site with dung from animals allowed to graze on the growing plants.

Primulaceae

Anagallis arvensis L. type. Archaeological material consisted of small angular seeds (1mm), which were smooth with a slight sheen. Modern seeds are finely papillose. Occasional charred seeds were present from phase 7 upwards and desiccated seeds from phase 4 upwards. It occurs as a cosmopolitan weed of cultivated land.

Rubiaceae

Galium sp. Glabrous fruit, 2.5mm diameter. *Flora of Libya* (Ali and Jafri 1976-) gives 10 species including common arable weeds. Single charred specimens were present in the Jarma material in two samples (05F/386 and 05F/389).

Rutaceae

Haplophyllum sp. (fig. 5.31). Both capsules and seeds were present. The seeds only occurred with capsule fragments and are therefore presumed to have been freed post-deposition. Whole fruit fragments were present with 2 to 5 (of 5 to 6) capsules or segments remaining. Capsules are glandular, rounded above, with 2 seeds per capsule. Each capsule segment is 2.5mm. The seeds are rounded-reniform and ruggose, and measure 1 x 0.6mm. *Flora of Libya* (Ali and Jafri 1976-) gives one species, *Haplophyllum tuberculatum* (Forsk.) Juss., a desert species, usually low growing (15-40, up to 60cm) which flowers early summer (May to June). It occurs in two samples only, both represented by seed head/capsules and seeds: sample 01S/022 (desiccated) and 04I/128 (charred).

Resedaceae

Reseda cf. *lutea* L. A common desert/steppe species which is represented in the samples by ovoid-subreniform seeds, with a slightly papillose or shiny surface (fig. 5.32). Seed dimensions were 1.2x0.6x0.5mm. Charred seeds were fairly numerous in phases 6 and 5, absent in other phases.

Reseda villosa/alba. Seeds of this taxa were tuberculated, and measured 1.2x0.8x0.6mm (fig. 5.33). The seed could not be satisfactorily distinguished between the two species. Both species are spring flowering. *R. villosa* is a tall tropical desert species while *R. alba* is sometimes cultivated as an ornamental.

Scrophulariaceae

Linaria sp. A flat, papery seed, square to circular, papilose centre on both upper and underside, 2mm diameter. The seed was similar to *Linaria vulgaris* or *L. kurdica* in the UCL reference collection, but other species could not be ruled out. *Flore du Sahara* (Ozenda 2004) lists four species: *Linaria aegyptica*, *Linaria sagittata*, *Linaria laxiflora*, *Linaria pertieri*. One charred and one desiccated seed were present in sample 05S/411, one charred seed in sample 06F/534 and one desiccated seed in sample 03S/364.

Solonaceae

Solanum sp. Seeds were orbicular or sub-reniform, rugose, compressed, measuring 1.5-2.0x1.2-1.5 mm. This is a large genus which contains several cultivars including New World species. Upwards of 200 species are known in Africa of which *Flora of Libya* (Ali and Jafri 1976-) lists 2 cultivated (*S. tuberosum*, potato, and *S. melongena*, African egg-plant) and 3 wild species (*S. nigrum*, *S. sublobatum* and *S. sodomeum*). The seeds of *S. melongena* are much larger than the archaeological specimens (3-5 x 2.5mm). *S. nigrum* is an annual herb, of which there are two sub-species, var *nigrum* grown as a medicinal plant and a pot herb, and var. *villosum* which has a more coastal distribution. The seeds compare well with the archaeological material. *S. sublobatum* is a perennial weed of waste places, while *S. sodomeum*, which has a much larger cell structure, grows in nitrophilious waste habitats. *Flore et Vegetation du Sahara* lists *Solanum nigrum* only (Ozenda 2004). Burkhill lists 25 as indigenous to West Africa (2000), several of which are cultivated for their fruits or berries, including *Solanum incanum* aggregate (aubergine), *S. macrocarpon* (African egg-plant) and *S. melongena* (aubergine). Several species also have medicinal uses. As a weed the genus is most commonly associated with disturbed land or there are several which colonise rice fields in West Africa. In the archaeological samples there are numerous charred seeds from phase 6/7 onwards, but no desiccated seeds.

5.4 Wild Fruits and Trees

A range of wild fruits and trees are represented in the samples by fruits, seeds, leaves and flowers. Such material may have entered the site via deliberate collection for animal or human food, with building material or fire wood, animal bedding and so on. Alternatively material may derive from plant species growing on or around the site or on the edges of threshing floors.

Zizyphus spina-christi (L.) Desf. (Christ's thorn), family Rhamnaceae. Represented by whole or fragments of globular, deeply ruggose, ± spherical fruit stone. The stone frequently splits into two lateral and one central segment revealing two seed cavities. Rare charred fruit or fruit fragments were present from phase 7 to 5. Fragments of stone were difficult to distinguish from *Olea europea*. The fruits are widely collected for human and animal consumption.

Prosopis sp., family Mimosaceae. The archaeological seeds are sub-circular to oval, 4.0-4.5 x 2.8-4.0mm, compressed with a visible areole (fig. 5.34). One cultivated species is given in Flora of Libya, *P. juliflora* (Swartz) DC., a straggling shrub, up to 5m, generally armed with paired stipular spines up to 1cm long and introduced from the New World (Ali and Jafri 1976-). The seeds compare well with *Prosopis farcta* (=*Lagonychium farctum*), although are smaller than the reference material held by the Institute of Archaeology, UCL. Charred seeds are present in small numbers from phase 7 onwards.

cf. Mimosaceae thorns. This type consists of paired stipular spines of varying length up to 1.5cm (fig. 5.35) which are characteristic of *Acacia* spp. but could not be confirmed to any genus. A deposit of 40 desiccated pairs of thorns was present in sample 03CF/046, while charred examples were recorded from phase 7 to 3 with a large deposit of 61 charred examples in sample 07CF/549. Sample 07CF/549 also produced a number of *Prosopis* type seeds, raising the possibility that these are of the same species. The presence of sometimes quite large deposits of detached thorns is unusual and difficult to explain. The thorns may have entered the assemblages with fire wood, or have been removed deliberately from building wood, animal feed, fencing and so on.

Tamarix sp. (tamarisk), family Tamaricaceae. Both leaf shoots and occasional desiccated flowers were present in the samples. The leaf shoots are variable in size and shape and no attempt was made to identify them to species. Tamarisk trees are abundant in the area and around the rest house at Jarma where the sample processing took place. While contamination with modern specimens during sample processing was kept to a minimum it is likely that leaflets have blown into the site throughout its history and that this includes recent contamination of archaeological deposits. The leaflets tended to occur in large quantities in the desiccated samples, a total of 1490 being counted. One desiccated flower was identified from sample 01S/004. A total of 69 charred leaf shoots were counted in 5 samples. Tamarisk are quick growing, deep rooted drought resistant and salt-tolerant tress and shrubs, which grow in most deep desert wadis and on river banks (Townsend and Guest 1966-). The wood is much used in the Fazzān for building material and fuel given the scarcity of timber in the region. It is possible that the branches and leaves were collected for fodder. This has also been suggested for Zinkekra, where the elevated position of the site would suggest leave shoots did not simply blow into the deposits (Van der Veen 1992).

5.5 Unidentified Seeds

A range of distinct and well preserved seeds have not yet been assigned to genus or family and at the present time are recorded by codes.

'Jarma type W' Possibly a Rubiaceae, this seed is slightly globular with a central hilum or embryo in an indentation in the centre of the ventral surface (fig. 5.36). The dorsal surface is convex and rounded. An irregular, small, tightly packed cell structure is visible on the surface. The seed measures 1x1mm. Three charred seeds in sample 06F/534.

'Jarma type T' (fig. 5.37). This type is represented by a small, largely featureless rounded seed or fruit, 1mm in length. The seed has an oval plan, with a smooth circular dorsal surface and flattened ventral surface with two short narrow curved scars at the apex. The apex is slightly acute. This seed is quite common with 80 in total from phase 7 to 3 and a deposit of 33 in sample seeds 07S/592.

'Jarma Type F' These seeds are always distorted and broken with a glassy appearance, apparently having a high oil content. The shape is variable but they have a consistent texture. Present in small numbers from phase 6 to 3.

'Jarma Type 5' Twisted linear seeds, about 2mm in length. One charred example was present in sample 03F/367 and three desiccated examples in phase 5 samples.

5.6 Unidentified Non-Seed Remains

Myriophullym/Zylophyllum sp. Desiccated (or modern) lengths of stem, pinkish colour, with ribbed segments of variable length, claw like at the top end of each segment (fig. 5.38). They are thought to be the stem segments of an aquatic or semi-aquatic herbaceous plant. They are present in phases 1, 2 and 3 sometimes in fairly large numbers. Presumably the plant had been collected for animal feed or bedding or possible roofing. It tends to occur in samples with large quantities of chaff, leaves, tamarisk shoots and possible fodder plants.

'Jarma Type P'. Small fleshy, obovate leaves of variable size. Charred examples are present from phase 7 onwards, particularly in phase 3 where two deposits of 10 leaves each were counted in samples 03PF/105 and 03RF/108. They are also common as desiccated leaves, with deposits of 38 in sample 03CF/046. They may have entered the site with firewood, or as animal fodder, or may represent a herbaceous species collected deliberately or simply growing on the site.

In addition a range of less well preserved and unidentifiable fragments, flowers, thorns and so one were recorded in the samples. The type of material has been noted but no attempt at identification made.

5. 7 Broad Trends by Historical Period

Table 5.1 shows a summary of the crops identified at Jarma, Tinda and Zinkekra in each phase. The data for Zinkekra were taken from Van der Veen (1992). The individual species recorded at Jarma and Tinda have been discussed above. The broad trends in the crop data are presented here before the implications of changing irrigation and labour requires and evidence of the changing nature of the arable economy are discussed. The changing arable economy is discussed further in chapter 8 with reference to archaeological finds and other evidence for the changing dietary and other cultural habits.

Table 5.1: A Summary of the Crop Occurrences per Phase

	Phase 1-2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 6-7	Phase 9-10	Tinda	Zinkekra
	Post Medieval	Late Medieval	Early Islamic	Late Garamantian	Classic Garamantian	Prot-Urban Garamantian			Early-Garamantian
				3^{rd} to 9^{th} century AD	2^{nd}-6^{th} Century AD	500-1BC			c.900-400BC
Triticum aestivum (bread wheat)	*	*	*	*	*	*	*	*	*
Triticum cf *durum* (durum wheat)		*		*	*	*			
Triticum dicoccum (emmer wheat)							*		*
Triticum dicoccum/monococcum (emmer/einkorn wheat)					*		*		
Hordeum vulgare (hulled, six row barley)	*	*	*	*	*	*	*	*	*
Pennisetum glaucum (pearl millet)	*	*	*	*	*	*	*	*	
Sorghum bicolor (cultivated sorghum)	*	*	*		*	*		*	
Zea mays (maize)	◆								
cf. *Vicia* faba (fava/ fûl bean)	*			*					
cf. *Pisum* sp. (pea)	*				*				
cf. *Lens esculenta* (lentil)		*	*						
cf. *Vigna unguiculata* (cow pea)	*								
Leguminoseae (indeterminate pulse)		*	*	*	*	*			
Ficus carica (fig)	*	*	*	*	*	*	*	*	*
Vitis vinifera (grape)		*	*	*	*	*	*	*	*
Phoenix dactylifera (date)	*	*	*	*	*	*	*	*	*
Citrullus lanatus (water melon)	*		*						
Citrullus sp. (watermelon/bitter apple)					*	*			

	Phase 1-2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 6-7	Phase 9-10	Tinda	Zinkekra
	Post Medieval	Late Medieval	Early Islamic	Late Garamantian	Classic Garamantian	Prot-Urban Garamantian			Early-Garamantian
Cucurbita sp. (pumpkin/squash)	*								
Cucumis sp. (melon/cucumber)	*			*					
Lagenaria sp. (gourd)	♦	*		*	*				
Cucurbitaceae (indeterminate cucurbit)	*	*	*	*	*	*			
Capsicum sp. (pepper/chili)	*	*?	*?						
Prunus amygdalus (almond)		*		*	*				
Prunus persica (peach)	♦								
Punica granatum (pomegranate)				*	*	*			
Nigella sativa (black cumin)	*								
cf. *Cumin cyminum* (cumin)	*								
cf. *Coriandrum sativum* (coriander)				*					
Anethum graveolens (dill)									
cf. *Foeniculum vulgare* (fennel)									
Olea europea (olive)				*		*			
Olea/Zizyphus sp. (olive/Christ's-thorn)		*	*	*	*				
Linum usitatissimum (flax/linseed)	*	*	*	*					
Gossypium sp. (cotton)		*	*	*	*	*	*		
cf. *Sesamum indicum sp.* (sesame)						*			

♦ - present in 2mm or 4mm sieve only
*** - present in sorted samples**

5.7.1 The Early Garamantian Period (900-400BC) and the Beginnings of Agriculture

At present we still lack archaeobotanical material from settlement sites which cover the transition from pastoral to agricultural farming in the region. Early and mid-Holocene pastoral sites in south western Fazzān suggest the systematic collection of wild grasses (Wasylikowa 1992; 1993; cf. Castelletti *et al.* 1999; Cottini and Rottoli 2002; Mercuri 2001), but this does not appear to have resulted in any indigenous domestication. One crop plant which may have been cultivated in the Fazzān in an earlier period is *Phoenix dactylifera* (the date), stones of which were recovered from a burial in the Wadi Tanezzuft near Ghat, dating to the end of the 2nd millennium BC (Cottini and Rottoli 2002, 174, 179). Cottini and Rottoli suggest that these dates could have been 'exotic' imports from Egypt (*ibid.*). It is equally conceivable that the date was already being cultivated in the Wādī al-Ajāl area which is well over 1000 km closer than the nearest Egyptian oasis. Three stones of *Phoenix* sp. were also recovered from the upper pastoral deposits at Uan Muhuggiag (Wasylikowa 1992; 1993), one of which produced a radiocarbon date of 2130±70bp (OxA-4389; Van der Veen 1995), further suggesting links between pastoral populations and settled farmers, by this stage presumably in the Wādī al-Ajāl area. While the Fazzān is within the current zone of wild and feral varieties of *Phoenix* it is thought that the origins of domestication centre on the Near East (Zohary and Hopf 1994). The absence of *Phoenix* sp. in any earlier deposits within the Acacus rock shelters would suggest wild forms were not native to the southern Fazzān.

The earliest archaeobotanical evidence for agriculture in the Fazzān is derived from the promontory site of Zinkekra and suggests that a regime based on Mediterranean or Near Eastern crops was already well established by the early part of the 1st millennium BC (Van der Veen 1992). *Triticum dicoccum* (emmer wheat) and *Hordeum vulgare* (barley) provided the staple cereal crops, while some evidence for *Triticum aestivum* (bread wheat) was also present, all of which must have been cultivated as winter cereals. The cereals were supplemented by *Vitis vinifera* (grape), *Ficus carica* (fig) and *Phoenix dactylifera* (date).

Some of the herbaceous species recorded may also have been cultivated, such as *Apium graveolens* (wild celery), *Anethum graveolens* (dill) and *Foeniculum vulgare* (fennel). A series of eleven radiocarbon dates on seeds and charcoal range from 2695±100 to 2410±120BP giving a calibrated date range of 900-400 cal BC (Van der Veen 1992). Recalibrated probability curves for these dates cluster around 800 BC (Mattingly *et al.* 2002, 12) suggesting that the transition to agriculture had already occurred early in the first millennium BC. The absence of evidence for the cultivation of indigenous African cereals (particularly *Pennisetum glaucum* or *Sorghum bicolor*) suggests that agriculture did not develop out of a localised exploitation of wild grasses. Furthermore arboriculture is not typical of pioneer agriculture, which tends to focus on cereals, suggesting that a fully developed package including cash crop fruits was introduced from elsewhere, presumably from the Nile Valley or oasis settlements in the eastern Sahara. It is possible therefore that the initial emergence of agriculture in the Fazzān involved a complete package of specialised oasis garden style cultivation introduced in the late second or early first millennium BC, possibly by new populations or small groups of individuals moving into the area from more easterly oases (di Lernia *et al.* 2002, 298-302; Mattingly *et al.* 2003a, 342-46), possibly as a result of increased aridity and population pressures in the more established oasis centres.

The weed flora at Zinkekra included species of wet, swampy or marshy areas including *Phragmites australis* (common reed) and numerous seeds of *Cyperus* cf. *laevigatus*, *Eleocharis* cf. *caribaea* and *Cladium mariscus*. These species suggest fairly wet ground conditions were present, which could include irrigation channels. The weed flora also includes common arable weeds, weeds of desert/steppe environments, including grasses, and low succulent plants which may have grown in irrigation channels.

5.7.2 Garamantian Proto-Urban Phase

The final centuries of the 1st millennium BC are known to be a period of innovation and social development in the Fazzān. The botanical data generated by the excavations at Jarma phases 10 to 6/7, and that collected from Tinda B would seem to suggest that this is also reflected in arable developments. A range of new crop plants appear for the first time in Jarma and at Tinda. These include fruit crops which must have been introduced from either the Nile Valley or the north such as pomegranate and olive, but is also reflected in a change in the staple cereal crops. As the fruit crops are only present in small numbers their significance is difficult to establish. Equally the significance of their absence at Zinkekra is difficult to assess. Given the number of samples taken from Zinkekra and the high degree of preservation at the site their absence is assumed to reflect a real trend rather than a product of preservation.

As at Zinkekra two wheat crops are recorded for this period, *Triticum dicoccum* and *T. aestivum* as well as *Hordeum vulgare*, which continued to form a major component of the assemblages. In addition the two sub-Saharan summer cereal crops, *Pennisetum glaucum* and *Sorghum bicolor* are recorded for the first time. There is also some evidence for *Gossypium* sp. (cotton) in the early Jarma phases, although the low numbers and small size of the surviving fragments might suggest a risk of contamination from upper levels. Two seeds of possible sesame, *Sesamum indicum* were also identified from this phase from sample 07CF/549.

Generally, with the exception of sample 07CF/549, the weed flora in the early deposits at Jarma is minimal consisting of occasional grasses including *Phalaris* sp., *Brachiaria ramosa/deflexa* and *Digitaria* sp., as well as *Chenopodium murale*, *Fumaria* sp. *Euphorbia helioscopia* and occasional Cyperaceae. The range of species is much more restricted than at Zinkekra, and the only new taxa are *Brachiaria ramosa/deflexa* and *Digitaria* sp., possibly weeds of summer crops, and *Euphorbia helioscopia*, a common arable weed. No species of wet ground were recorded. The weed flora at Tinda was very limited, restricted to occasional small and large grasses most of which had presumably remained with the processed barley crop.

Jarma sample 07CF/549 stands out from the other samples in this period in both the range and number of weed/wild species present, several of which were not recorded at Zinkekra. Particularly numerous were the utricles and possible seeds of *Cornulaca monacantha*, capsules of Cruciferae Type V and pods and seeds of *Alhagi* type seeds and small seeded Fabaceae. *Cornulaca monacantha* and *Alhagi* sp. are common desert shrubs, the number of seeds present suggesting some sort of collection, possibly for fodder. Seeds of *Vicia/Lathyrus* sp. are another leguminous weed not present at Zinkekra. Again these might represent fodder species, but may also be arable weeds, particularly of cultivated legumes. The grasses included seeds of *Setaria verticillata*, *Brachiaria ramosa/deflexa* and *Setaria/Brachiaria/Echinochloa* type, none of which were identified from Zinkekra, as well as other unidentified Paniceae grain. *Amaranthus augustifolius, Reseda villosa/alba*, *Heliotropium* cf. *europaeum* and *Suaeda* sp. are arable weeds, particularly of desert or sandy areas, while *Suaeda* sp. is tolerant of saline conditions. Of these species only *Reseda villosa/alba* was recorded at Zinkekra.

Assuming sample 07CF/549 does not contain contaminated material from higher deposits (the sample did produce an appropriate date for this phase of (10 cal BC - cal AD 140)), the generally limited weed flora of this period does include a range of new species not identified at Zinkekra. Most noticeably the flora of this period does not contain taxa of wet ground. Possibly there is a general increased diversity of the weed flora to include more common arable species but also more desert species, particularly tropical (summer flowering) grasses, as well as some possible fodder crops. The presence of large amounts of leguminous weeds including possible *Alhagi* sp. as well as *Cornulaca monacantha* may be related to a change in animal husbandry practices, for example the housing and feeding or large animals, such as camel.

5.7.3 Classic Garamantian Period (Phase 6)

Throughout the Garamantian period there appears to have continued to be an introduction of new crops, although some of the fruits in particular may have been imported. *Hordeum vulgare* continues to be the most numerous and ubiquitous cereal species, while *Triticum aestivum* and a new wheat species, *Triticum* cf. *durum,* are also present. *Triticum dicoccum* is no longer represented in the samples. *Sorghum bicolor* is tentatively identified and *Pennisetum glaucum* is present in several samples, if in small numbers. It would therefore appear that the summer crops which were introduced in the latter part of the 1st millennium BC were an established part of the arable economy by the early first millennium AD. Large seeded, presumably cultivated, pulses are recorded for the first time including a possible pea, *Pisum sativum.*

The range of fruit species is slightly extended in phase 6 to include cucurbits (*Citrullus* sp. and *Lagenaria* sp.), while possible imported fruits are also present (*Punica granatum* and *Prunus amygdalus*). Olive, *Olea europea*, may be present although the fragment of stone could not be distinguished from *Zizyphus* sp. Seeds and seed fragments of *Gossypium* sp. are reliably identified from phase 6 while an AMS dated seed confirms that it was present by the second or third century AD (140 - 380 cal AD). A single seed of possible sesame, *Sesamum indicum* was also identified.

At least 38 distinct weed/wild taxa were identified from phase 6, in addition to a range of unidentified poorly preserved items. Generally, however, weeds were present in low numbers. The range of species is broadly similar to proceeding phases and includes a range of species which were present at Zinkekra. Grasses tend to dominate as they do in all phases. *Polypogon* sp. is a grass species not recorded previously, while seeds of *Phalaris* sp. and *Setaria/Brachiaria/Echinochloa* type were fairly numerous. Fabaceae weed species are present but in small numbers compared to the phase 7 sample 07CF/549. The majority of the species recorded had been identified from earlier deposits and are common weeds in desert areas, including *Asphodelus tenuifolius/fistulosus* and *Chenopodium murale*, *Suaeda* sp., or *Reseda* cf. *lutea*. Species not previously recorded at any of the sites in the area are cf. *Calendula* sp., *Euphorbia peplus, Fumaria* sp. cf. *Papaver somniferum* and *Linaria* sp., all arable weeds. *Aizoon* cf. *hispanicum*, also present at Zinkekra, is a low succulent plant which may have been growing in irrigation channels. Seeds of *Solanum* sp. and indeterminate Solonaceae have also not been identified from earlier deposits at Jarma or Zinkekra. While the numbers of the seeds are not significant in phase 6 they become so in later deposits suggesting this to become either a well established weed or a species of some economic significance. As discussed above the genus is a large one and contains several species of some economic use. Weedy varieties are characteristic of nitrogen rich soils, possibly therefore associated with manuring.

5.7.4 Late Garamantian Period (Phase 5)

The major difference between this and the preceding phase is the increase in the number of seeds of *Gossypium* sp. A total of 45 seeds were identified, present in 8 of the 17 samples in this phase. *Hordeum vulgare* dominates the cereal assemblage while *Triticum aestivum*, *Triticum durum*, *Pennisetum glaucum* and *Sorghum bicolor* are all present. *Pennisetum glaucum*, while still not numerous seems to be more common than previously. Pulses are present although rare, and include one seed of possible fava or fûl bean (cf *Vicia faba*). Olive, *Olea europea* is positively identified for the first time. In addition the possible 'luxury' or imported fruits, *Punica granatum* and *Prunus amygdalus* continue to be represented. One possible oil crop was represented, flax or linseed, *Linum usitatissimum*. In addition there appears to be some exploitation of wild tree species suggested by the seeds of possible *Prosopis* sp. and *Zizyphus spina-christi*.

Overall, the crop remains indicate a general expansion of agriculture from the end of the 1st millennium BC which continues into the Classic and Late Garamantian period, to include water hungry high risk crops and perhaps with some specialist cultivation of cash crops (e.g. cotton). An arable production involving a two cropping system of both winter and summer cereals as well as perennial fruits and a range of minor crops appears to have been well established by or during this period.

At least 44 distinct weed/wild taxa have been identified. Grasses continue to be numerous particularly those of *Brachiaria ramosa/deflexa* type, *Setaria/Brachiaria/Echinochloa* type, and indeterminate Paniceae, but also now *Panicum repens*. and *Phalaris* sp. The arable weed flora remains much the same as in the previous phase with the addition of some new taxa including *Galium* sp., *Malva* sp., at least two genus of Boraginaceae, possible *Apium graveolens* (this may represent an aromatic herb), *Linaria* sp., *Plantago* sp., and *Silene* cf. *gallica*. Seeds of *Solanum* sp. are particularly numerous. The unidentified seed Apiaceae Jarma A appears for the first time in this phase, while Type T and Type F are fairly numerous. Species of wet or damp ground are represented for the first time in the Jarma deposits, although in low numbers with Cyperaceae A and a single *Cladium mariscus*. Generally a more diverse weed flora is suggested in the phase, possibly with a greater number of summer flowering, Paniceae type grasses and maybe some indication of manuring practices from the increase in *Solanum* sp.. The wet ground species may derive from irrigation channels, or permanently wet ground in the vicinity or wells, or open water. The majority of the new taxa present are typical arable weeds of temperate climates and may have been introduced to the region with crops from the Mediterranean or Nile Valley regions. Alternatively these species may always have been present in the weed flora but were not sufficiently well established to have entered the archaeological record.

5.7.5 Islamic Period (phase 4)

The Early Islamic and later medieval period samples include the same suite of cultivated crops as the Garamantian period with the possible addition of a new free-threshing wheat variety, *Triticum* X type, present in one sample and a single possible lentil *Lens esculenta.* The major differences appear to be an increase in the number of grains of *Pennisetum glaucum* and the decrease in *Gossypium* sp., although it is not possible to judge the extent to which this reflects changing arable conditions or is simply a reflection of recovery. Generally therefore, this appears to be a period of continuation rather than innovation and there is no evidence from the range of crops present of any sort of 'Islamic agricultural revolution' (Watson 1983). A single seed of the New World genus *Capsicum* sp., in sample 04PF/107 is likely to be a contaminant from a later phase.

The weed flora contains a slightly reduced list of taxa with at least 31 distinct taxa identified. Arable or desert weeds continue to be represented, for example *Amaranthus* sp., *Anagallis arvensis* type, *Asphodelus tenuifolius/fistulosus, Chenopodium murale, Euphorbia helioscopia* and *Euphorbia peplus.* Species possibly derived from irrigation channels include *Aizoon* cf. *hispanicu*m and *Portulaca oleracea*, the later species not previously recorded as Jarma although present at Zinkekra. Grasses are the most numerous group of weed species present, particularly caryopses of *Hordeum* sp. and *Brachiaria ramosa/deflexa* type and *Panicum repens*. Also numerous are seeds of *Solanum* sp., particularly concentrated in one sample, 04I/128. Species not previously recorded are *Calendula* cf. *arvensis/tripterocarpa,* an arable weed, *Haplophyllum* sp., a low growing desert species, of which capsules were present with seeds intact, and *Dactyloctenium aegyptium*, a common grass of sandy soils in shady and moist places during warm months. Seeds of the desert shrubs, *Cornulaca monacantha* and possible *Alhagi* sp. are present but in small numbers in the charred samples. Sample 04PF/107 contains significant quantities of desiccated material which includes a large deposit of *Portulaca oleracea*, some of which was incorporated in animal droppings, and pods and seeds of *Alhagi* sp. However, as discussed in chapter 4, this sample is out of character with the rest of the phase and is potentially derived from a much more recent deposit.

5.7.6 The Late Medieval/Early Modern Period

The Late-Medieval/Early Modern period, represented by phases 1 to 3 is a period of agricultural development possibly as significant as the Garamantian period in that it includes the introduction of the New World crops. These phases also produced samples with a significant desiccated component, desiccated remains being more numerous than charred remains.

Three major crops were introduced: *Zea mays* (maize), *Cucurbita* sp. (pumpkin/squash) and *Capsicum* sp. (chilli/peppers). The last of these was present in large numbers as both charred and desiccated seeds. The Old World cereals, *Triticum aestivum*, *Hordeum vulgare*, *Sorghum bicolor* and *Pennisetum glaucum* are recorded in large quantities, but with the summer crops significantly outnumbering the winter ones, particularly amongst the desiccated remains. There is probably a change in the sorghum variety recorded in these later deposits, with race *durra* positively identified. Seeds or stones of *Phoenix dactylifera* and *Ficus carica* continue to dominate the fruit crops as in the previous phase, but in these later horizons evidence of *Vitis vinifera* (grape) is limited. *Gossypium* sp. does not appear to be represented by this period, although it does appear to have been occasionally cultivated in the Fazzān in the recent past. Seeds and capsule fragments of flax or linseed, *Linum usitatissimum* are more numerous than in earlier phases, the presence of the several desiccated capsule fragments perhaps indicating the use of the seed rather than the fibre, although not disproving the production of fibre. Two further condiments represented are *Nigella sativa* and possible cumin, cf. *Cumin cyminum.*

The weed taxa indicates an essentially well established flora which had changed little from the preceding period. Common arable weeds are again present such as *Amaranthus* cf. *augustifolius, Anagallis arvensis* type, *Chenopodium murale, Silene* cf. *gallica* and *Euphorbia peplus.* Grasses are particularly numerous, especially *Cynodon* type and *Panicum* A. Taxa recorded for the first time include *Eleusine* cf. *indica*, a summer weed of arable crops and two large seeded grasses, *Lolium* sp. and *Festuca pratensis* gp., both common arable weeds of wheat and barley. In addition to the arable weeds pods and seeds of the desert shrub *Alhagi* sp. are particularly common, possibly collected for fodder or derived from dung, and seeds of *Portulaca oleracea*, again possibly derived from dung. Tree species are represented by seeds of *Prosopis* and/or *Acaci*a sp., and *Tamarix* sp., the leaf shoots of which are exceedingly numerous in the desiccated deposits. Wet ground species are slightly better represented than in previous phases with 14 desiccated seeds of *Cladium mariscus.* Finally, the desiccated stem fragments of an unidentified aquatic species (possibly *Myriophullym* sp. or *Zylophyllum* sp.) were numerous in phase 1-3, possibly collected from the open water which was present behind the site until the late-20th century.

5.8 Discussion: Evolving Agricultural Practices in the Wādī al-Ajāl

5.8.1 The Crop Plants

Several points can be raised about agriculture in the Wādī al-Ajāl and its long term survival from the crop plants themselves. The archaeobotanical evidence recovered from sites in the Wādī al-Ajāl to date suggest that arable agriculture was established by the early part of the 1st millennium BC based on the Near Eastern staple cereals, emmer wheat and barley, with some bread wheat, the perennial fruits dates, grapes and figs, and possibly also aromatic herbs. The weed seeds are typical of arable weed floras and desert environments, with good evidence for quite wet ground in the vicinity. The data generated from Jarma and Tinda B now demonstrate that during the course of the Garamantian period some major innovations took place.

While hulled barley was always a major cereal cultivated in the region the type of wheat cultivated changed in accordance with widespread changes in wheat cultivation across North Africa, the Mediterranean and Europe. A widespread shift from hulled to free-threshing wheat is known to have occurred in Egypt in the late 1st millennium BC, the Mediterranean in the early 1st millennium BC and northern Europe in the 1st millennium AD (Zohary and Hopf 1994). A similar shift is known to have taken place in Libya. The timing has not previously been clear although it is believed to have occurred during the late 1st millennium BC (Van der Veen 1995). The evidence from Jarma supports this interpretation that this change took place in the later centuries BC, emmer wheat being very rare in the Jarma samples while forming a significant component of the samples from Zinkekra (Van der Veen 1992). Similarly, no emmer wheat was recovered from the 1st to 7th century AD sites sampled as part of the UNESCO Libyan Valleys Survey of Tripolitania (Van der Veen, Grant and Barker 1996), while emmer was recorded from deposits in the mid-first millennium BC site of Eusperides, Benghazi (Pelling and el-Hassey 1998).

A second widespread innovation in terms of wheat cultivation, also seen at Jarma was the introduction of durum or hard wheat (*Triticum durum*), a tetraploid free-threshing wheat. Free-threshing tetraploid wheat rachis was identified from sites within the Libyan Valleys survey area, particularly from a 5/7th century AD gsur (Van der Veen, Grant and Barker 1996). The Jarma evidence suggests it was present from the Classic Garamantian period (phase 6) so potentially a Roman introduction to Libya, and slightly earlier than the Tripolitanian evidence suggests. While bread wheat is generally regarded as producing superior bread flour, durum wheat is regarded as the more suitable to Mediterranean climates and was often assumed to be the free-threshing wheat species present (Zohary and Hopf 1994). It is significant therefore that at Jarma, as in the Libyan Valley Surveys sites (Van der Veen, Grant and Barker 1996), *Triticum aestivum* always appears more numerous than *Triticum durum*. The presence of *Triticum* Type X in phase 4 also raises the possibility of other forms of free-threshing wheat, possibly an introduction which can be assigned to the early Islamic period, although the status of the crop and the species involved remain unresolved at this stage.

The most significant arable innovation in the Fazzān however, in the later part of the first millennium, was the introduction of sub-Saharan summer crops, particularly pearl millet and sorghum. Cotton, another summer crop was adopted by the early centuries AD. The minimum rainfall for cereal cultivation is 200 mm per year, thus cereal cultivation in the Fazzān must always have relied on either adequate irrigation or sufficiently high moisture levels at or near the surface. With the introduction of the summer crops the provision of water would have needed to be year round and in greater quantities. As discussed above cotton, a species of tropical environments, is a particularly demanding crop requiring the equivalent of 500mm of rain in water a year. While pearl millet is the cereal most tolerant of extremes of heat and drought, it originates from the savannah regions to the south of the Sahara where annual rainfall is at least 250mm a year. Furthermore, unlike sorghum, pearl millet requires its rainfall to be evenly distributed during the growing season.

As discussed in chapter 2, the exact timing of the introduction of the *foggara* is still unclear. The association of *foggara* systems with cemetery and settlement sites however indicate that they were certainly present by the 4th century AD and probably by the later centuries BC (Wilson and Mattingly 2003). It is thought likely that they were introduced to the region from Egypt where they were in use in the Western Desert by the 5th century BC, for example at 'Ayn Manawir, Kharga Oasis (Wuttmann 2001; Wuttmann et al 2000). It is tempting to suggest that the move from the settlements on the escarpment edge, such as Zinkekra, to the wadi floor was related in part to a change in irrigation system. It is unlikely that it will ever be possible to convincingly establish if the introduction of summer crops necessitated a change in irrigation system or if a new irrigation system enabled the cultivation of those crops. However, it is tempting to suggest an association and it would seem reasonable to suggest that once the new irrigation technology was in place more and more new water demanding or high risk crops could be introduced.

The introduction of the summer crops also implies a change to a two-cropping system whereby summer crops (those which rely on shortening day lengths for seed formation) are cultivated as well as the winter ones (those which rely on increasing day length). This would imply a profound change in the arable calendar and, consequently, a more productive and intensive use of land.

Finally, the evidence from both Zinkekra and Jarma suggests the presence of perennial fruits from the early part of the 1st millennium BC. The range of perennial fruits increased during the Garamantian period to include some difficult and demanding crops such as almond and pomegranate. The presence of an agricultural package in the early 1st millennium BC which included perennial fruits suggests that either agriculture was already well established or they had been introduced together by experienced agriculturalists. It is likely that the cultivation of fruits and field crops have a long association in the oases, the taller fruit trees, particularly date palms providing shade for more sensitive plants.

The Garamantian period therefore appears to be one of continued agricultural expansion and innovation with a significant number of new crops including high risk species. The Islamic period appears to be one of continuation or possibly even decreased agricultural diversity and risk. There is certainly not evidence for an 'Islamic agricultural revolution' (Watson 1983), the only potential new crop at this stage being *Triticum* Type X. The introduction of the New World crops in the later or post-medieval period represents a final period of innovation which again is likely to have had a profound impact on agricultural output as well as culinary traditions. The cultivation of a wide range of crop species, particularly such a diverse range of cereal crops is interesting. This could be regarded as a risk buffering exercise, the cultivation of a greater range of crops insuring against failure of any single crop. This tends to be a characteristic of subsistence production, as opposed to the state regulated extreme witnessed in Pharonic Egypt for example, where barley and emmer wheat were the principal cereal crops cultivated. In the Fazzān the increased diversity of crop species appears to be closely related to the introduction of the *foggara* system. *Foggara* must have involved a huge increase in labour and implies an increase in the intensity of production. Two-season cultivation also implies increased intensity of production which may have included an increase in productivity which could be seen as a means of making the increased labour demands economically viable. Increased crop diversity could be seen as an economically more productive system related to a period of increased material wealth.

5.8.2 The Weed Flora

While there are considerable similarities between the weed floras at Zinkekra and Jarma, primarily the presence of desert weeds and largely cosmopolitan weeds of winter cereals, there are some differences. There are a significantly greater number of seeds of wet ground species at Zinkekra than Jarma. Superficially this could simply reflect wetter conditions in the area in the early part of the1st millennium BC. If such species entered the archaeological deposits with harvested cereals it would indicate cultivation of cereals on partially wet or seasonally inundated ground. This could include irrigation channels, but it is significant that they are not numerous at Jarma when irrigation channels might be expected to be much wetter following the introduction of the *foggara.* Furthermore, *Cyperus laevigatus* and *Cladium mariscus*, are perennial herbs with creeping rhizomes. Such species might not be favoured by the intensively managed irrigation channels found in association with the multiple small arable plots traditionally farmed in the region today, due to the frequent hoeing and clearing of the shallow channels. Annual succulent herbs such as *Portulaca oleracea* conversely, do well in such irrigation channels, as do many of the annual grasses such as *Cynodon* species. Finally, most of the seeds of the wet ground species from Zinkekra were found in one context and included many incorporated in dung like material (Van der Veen, 1992, 35). If they entered the site via animal dung this still would imply wet conditions in the vicinity, but their presence in archaeological contexts may be related to animal husbandry rather than arable practices. A change in the abundance of these wet ground species might therefore reflect a reduction in the water table and consequently wet habitats in the vicinity of the site or the arable fields (or both), or it could represent a change in irrigation methods, or finally a change in animal husbandry practices.

A second difference in the wild flora between the two sites is the increase in the seeds and pods of potential fodder species. At Jarma these include the thorny desert shrub *Alhagi* sp.

as well as *Cornulaca monacantha*, the grass *Cynodon* sp. and *Portulaca oleracea*, both present at Zinkekra, as well as some less numerous taxa. This last species was found incorporated in sheep/goat droppings at Jarma. The two former species are desert shrubs, *Alhagi* sp. with thorns, both of which are eaten by goats and particularly camel. The increase in these taxa may reflect a change in animal husbandry practices, which could include the introduction of the camel. Some changes in animal husbandry practices would be expected given the difference in site location, Zinkekra being a narrow promontory settlement on an escarpment. The presence of dung in deposits at Zinkekra does suggest at least some animals were present on the site but the location would limit it to sheep and goat, although dung may have been brought up to the site for fuel or building purposes. A significant change in the animal fauna would have been the introduction of the camel, presumably in the Garamantian period (camel is present in the bone assemblage at Jarma from phases 7 and 6/7, Britton and Grant, *forth.*). Camel may have been tethered or brought into the site or the dung may have been collected elsewhere and brought into the site for use as fuel.

The evidence for soil depletion or manuring is difficult to establish from the weed data and can only be surmised. The agricultural system practiced today is an intensive one where soil fertility is maintained by the addition of large quantities of organic matter rather than by crop rotation or fallow systems. The high salinity of the soil was referred to by Herodotus (Histories IV.183) and must always have been a problem. Extensive salt crusts form rapidly following rain in the area. Barley is the most salt tolerant of the cereals and its dominance in the samples in all phases is likely to be in a part a reflection of that. However, there are not significant numbers of salt tolerant weed species present in the samples, *Suaeda* sp. being the only particularly salt tolerant taxa recorded. There is certainly no increase in its abundance through time. It is possible therefore that continued addition of organic matter onto arable plots prevented leaching of salts into the upper soil horizons and kept salt levels to a minimum. The addition of large deposits of manure onto arable plots is widespread in the Sahara. This is likely to be an ancient practice, again indicated by Herodotus who states that the Garamantes 'spread soil [also translated as humus] over the salt to sow their seed in' (Histories IV.183). Increased intensity of manuring may be indicated by the increase in the number of seeds of *Solanum* sp., nitrogen loving plants many of which are characteristic of manure or rubbish heaps.

5.9 Summary

The species recorded at Jarma and Tinda B now provide a really useful account of the development of agricultural practices in the Wādī al-Ajāl and complement the data generated from Zinkekra (Van der Veen 1992). The original package of Near Eastern staples, supplemented by perennial fruits and possible condiments, was established by the early 1st millennium BC. By the late 1st millennium BC a profound change in the crop repertoire involved the introduction of sub-Saharan cereals, while continued contact with the Mediterranean World and Egypt ensured the Garamantes also engaged in widespread shifts in the types of wheat cultivated. Far from being isolated in terms of agricultural development the Garamantes were involved in pan-regional trends incorporating both 'Mediterranean/Near Eastern' and 'African' cereals. The data suggests that the Garamantian period furthermore was one of increased crop diversity with the adoption of 'cash crops', notably cotton, as well as a greater range of fruit species, pulses and minor oil crops or condiments. Thus the period of greatest agricultural change and development is the period from the end of the 1st millennium to the middle of the 1st millennium AD. By the late-medieval period the establishment of trans-Saharan trade presumably facilitated the rapid introduction and adoption of New World crops, particularly maize and capsicums. Maize in particularly would have been incorporated in to the summer crop repertoire with ease.

The adoption of summer crops in particular and water hungry cash crops, as well as a potential increase in the range of perennial fruits must be associated with the introduction of *foggara* irrigation. It may never be clear whether the *foggara* enabled the adoption of the new crops of whether the cultivation of new crops required an improved irrigation system. If, as seems likely, the *foggara* were introduced from Egypt, then it is interesting that the new crops that were irrigated by them are largely derived from sub-Saharan Africa and, with the exception of cotton, were cultivated in the Fazzān **before** they were cultivated in the Egyptian oasis (see chapter 7).

Finally, while the rate of change of agriculture in the region slowed following the decline of the Garamantes and some of the 'luxury' fruit crops are no longer present, the range of crops and the weed flora actually changed little prior to the introduction of the New World species. Cotton appears to be less well represented by the Islamic period and grapes are rare in the late-medieval/early-modern deposits, but otherwise the range of crops and the weed flora are fairly constant. Agriculture must always have been intensively practiced and required irrigation, while the need for enrichment of the naturally poor soil was equally necessary.

The following chapter examines sample composition in terms of crop processing activities and sample formation. Chapter 7 re-examines the species present in terms of what they add to our knowledge of crop history across North Africa and attempts to trace the development of both crop and weed flora through time and space.

Chapter 6

SAMPLE COMPOSITION: NUMERICAL ANALYSIS AND EVIDENCE FOR CROP PROCESSING

6.1 Introduction

The range of species and the type of plant parts present in each phase were discussed in chapters 4 and 5 in terms of their implications for the arable economy of Old Jarma. This chapter explores the internal composition of individual samples in greater depth as a means of understanding the taphonomic processes behind sample formation. The relative proportions of plant parts are discussed for each sample with more than 30 items, taking into account feature type. Differences between desiccated and charred assemblages are highlighted. Numerical abundance and ubiquity of significant taxa are used as a simple method of exploring spatial and temporal differences in composition and species significance. Various quantitative methods relying on ratios of different plant parts and types are employed to explore the potential of identifying possible crop processing activities or use of processing waste. Finally multivariate statistics are used to explore patterns in the dataset to highlight differences or similarities in sample composition.

6.2 Sample Composition by Phase

This section examines the differences in relative proportions of the major plant types (grain, chaff, weeds, oil plants, fruits etc). This was examined on a phase by phase basis in chapter 4. In this section the individual samples are examined. Several samples had only a small number of items and therefore any pattern in the data might be misleading. For the purpose of the numerical analysis which follows, samples with fewer than 30 items were omitted. Samples with fewer than 100 items may still be considered too small for compositions to be reliably representative. The figure 30 was selected to allow the maximum number of samples to be included without compromising reliability too much. Care is taken in the interpretation of samples with 30 to 100 items. Taxa identified in samples with more than 30 items were categorised and quantified as follows:

Cereal grain was counted on the basis of whole grains or embryo ends.
Cereal chaff includes glumes bases, rachis and culm nodes but not 'light chaff' items such as free-threshing glumes, lemma and palea fragments.

Sorghum bicolor chaff is quantified on the basis of spikelets. Glume fragments or glume bases were omitted from the calculations. *Pennisetum glaucum* involucres were counted and used in the analysis, while spikelets were omitted.

Weed seeds include any wild herbaceous taxa not clearly assignable to other categories. Given the limitations of the level of identification it is not possible to categorically separate all arable weeds from collected wild herbaceous and shrubby species or some cultivated herbaceous species. This category is therefore likely to include a range of wild non-arable weeds and some shrubs. Clearly this has implications for interpretation of the data in terms of crop processing waste and this will be taken into account in any discussion.

'Fruits etc' is dominated by perennial cultivated fruits such as grape, fig and date, but also includes wild fruits (*Zizyphus spina-Christi*), condiments (e.g. *Capsicum* sp., cf. *Coriandrum sativum*) and vegetable crops (e.g. *Cucumis* sp.). There is considerable cross over in these categories as well as difficulties in the taxonomic level of identification, so for ease of reference and visual representation they are categorized together. Olive is classed in this category as it is thought likely to be present in the samples as a fruit rather than an oil crop.

Oil/Fibre crops include flax and cotton.

Pulses Given the paucity of pulses in the samples all species are considered as a single class.

'Leaves etc' This category includes leaves, thorns and other quantifiable non-fruiting/flowering parts. While this category will include leaves which naturally blew onto the site it is also likely to include material brought into the site deliberately with fuel or building wood, or as fodder or bedding. Leaves tended to swamp the data for desiccated samples. The composition of desiccated samples is therefore explored with leaves both included and excluded.

6.2.1 Composition of Charred Samples

6.2.1.1 Phases 10 - 6/7

Samples in the Early Garamantian deposits tended to produce small assemblages. Four samples produced flots with more than 30 items, one from phase 9, two from phase 7 and one from phase 6-7. The relative composition of the major plant types is shown in figure 6.1. Sample 09F/599, from a 'spread' or floor, is clearly grain rich. The total number of items in this sample is just above the cut off point (35 items in total) and therefore the reliability of this sample may be considered suspect. The weed and the oil/fibre categories consist of one item each (1 grass seed and 1 cotton seed). The grain in this sample is entirely of *Pennisetum glaucum*. The phase 7 samples are both from large spread deposits, with 07CF/549 thought to be an external courtyard area. The assemblages are mixed with weeds, chaff and fruit remains dominating. Grain is rare in both samples. Finally sample 6/7PF551, taken from one of the large pits characterising the 6-7 intermediate phase is fruit rich, fruit remains forming over 85% of the assemblage. Grain, chaff and weed seeds are present in similar proportions in this sample. In composition this sample is more similar to phase 6 samples than to the phase 7 samples.

6.2.1.2 Phase 6

Ten samples from phase 6 produced assemblages with more than 30 items (fig. 6.2), eight of which were from floors or room fills. Two samples were from pit fills, one of which (sample 06PF/517) is interpreted as a fire or hearth. Fruit remains clearly dominate this phase forming more than 60% of seven of the samples. This category is dominated by perennial fruits, particularly fig, grape and date. Sample 06F/400 contained a greater proportion of chaff than the other samples (>50%), while samples 06F/402 and pit sample 06PF/414 produced more mixed assemblages. Oil/fibre crops were present in three samples, including the fire pit. In all three cases the crop involved is cotton. The number of items involved in several of the samples is not large (less than 100) which may be considered to skew the data. However it is significant that the composition is broadly comparable between samples regardless of sample size. The one sample which is significantly different (chaff rich 06F/400) is a large assemblage and the difference is therefore likely to be real rather than a product of assemblage size. This sample was taken from within a small (store?) room in the southern part of the trench, possibly associated with a second house.

6.2.1.3 Phase 5

A total of sixteen samples produced assemblages with more than 30 items from this phase. Multiple samples were taken from large deposits including context 607, a large, deep expanse of organic rich deposit in the southern, possible courtyard area. This deposit was sampled on a grid system in two spits, samples 05S/411 and 05S/415 being from the lower spit and samples 05S/382, 05S/385, 05S/387, 05S/390, 05S/398, 05S/408 and 05S/410 were from the upper spit. Unfortunately poor on-site records were kept for these samples and the exact location of some of the samples from the upper spit is unclear. Sample 05S/408 is from within the small room formed by walls 0581 and 0657. Samples 05S/385 and 05S/398 are from immediately to the south of the well, sample 05S/387 is to their west. The remaining samples are from the southern area of the trench, with sample 05S/410 taken from an area immediately to the west of wall 0599. The locations of samples 05S/382 and 05S/390 are not recorded. The spread of samples does allow for some identification of spatial patterning, although it should be considered that considerable mixing of these deposits may have taken place. Samples 05F/386 and 05F/389 were both taken from a spread of deposits (context 652) on the north western spur of the site left by Mohammed Ayoub's excavations. Sample 05S/393 was taken from a slightly earlier deposit in the same area. Samples 05F/363 and 05S/366 were taken from deposits sealed by the phase 4 house. Sample 05RF/401 was taken from deposits to the north of the well, sealed below the phase 4 house and thought to relate to the phase 5 structure. Finally sample 05PF/361 was taken from a pit immediately to the west of the well. The richer samples (larger numbers of identifications) therefore all derive from the large courtyard or house area in the centre and west of the site, while the rooms in the south west corner produced only poor assemblages (refer to fig. 4.10 for exact sample locations).

The samples from this phase were generally poor in grain as in preceding phases (fig. 6.3). All but one sample consisted of less than 20% grain. Three samples, sample 05F/389, 05S/393 and 05S/415, were chaff rich, the chaff forming more than 70% (c.90% in the case of sample 05F/389). Sample 05F/410 is regarded as weed rich (weeds forming c. 70%), while sample 05F/363 is rich in fruit remains (c.70%). The remaining samples are mixed, with fruit frequently forming a significant component. Cotton formed a significant component of sample 05PF/361. With the exception of weed rich sample 05S/410 and chaff rich sample 05S/415, the samples from large spread context 607 produced broadly similar, mixed assemblages, based on the proportions of the major plant groups. In general the nature of deposits from this period appears to be mixed, regardless of context type or area of the site. The chaff rich samples are from the southern courtyard or the north-eastern spur, all from 'spreads' while the weed rich sample is from the area immediately to the east of wall 0599. The one pit sample produced more cotton seeds than any other sample.

6.2.1.4 Phase 4

Five samples produced assemblages with more than 30 items, four from 'spreads' or 'floors' and one from a possible fire deposit. Three of the spreads or floors were internal, two from Room 4.1 and one from a room in the south-western corner of the trench. The possible courtyard fill from which sample 04CF/129 was taken (context 0469) and the 'fire patch' sample 04I/128 which was situated within 0468 (context 0468) were sealed below mud-brick packing in the north-western area of the trench to the north of wall 0466 and apparently outside the houses represented in this phase.

Chaff formed a significant component of the fire patch sample 04I/128 (53%) (fig. 6.4). The other samples were generally mixed, with fruit being noticeably rare in sample 04S/104. The samples from internal floor deposits produced modest sized, mixed assemblages. The two samples from the courtyard area (04CF/129 and 04I/128) produced much richer assemblages, particularly the sample from the 'fire patch'.

6.2.1.5 Phases 1-3

Only one phase 1 sample produced charred remains in any quantity, while there were no rich samples from phase 1-2 or 2. Sample 01S/022 was from a spread within room 1.4, and was dominated by chaff, forming just over 60% of the assemblage (fig. 6.5). Chaff and weeds together form approximately 80% of the assemblage, with grain, fruit and leaves forming the remainder. Eight samples from phase 3 produced assemblages with over 30 items. Four of those samples were still of modest sizes, each with less than 50 items (courtyard sample 03CF/046, pit fill sample 03PF/303 and floor or spread samples 03S/363 and 03F/367). Sample 03CF/046 was dominated by charred leaves. The composition of these samples is likely to be affected by the sample assemblage size however. The remaining four samples were taken from two pit fills (samples 03PF/106 and 03PF/105) and two spreads or floor deposits, of which 03RF/108 is from a possible storage area or bin and 03F/102 is from a deposit within large room 3.1. Both pit fill samples are particularly large. All four of these samples are mixed with no single category dominating. Samples 03PF/105 and 03RF/108 are dominated by chaff and weed seeds, the combined totals forming over 70%. Sample 03F/102 is very mixed with grain, chaff, weeds and fruit present in similar numbers. Pit sample 03PF/106 is also mixed but does contain a greater proportion of grain than the other of these larger samples. Generally, if the small assemblages are excluded as unreliable, fruit remains form a far less significant component of the samples than in previous phases.

Sample (03PF/105) is believed to be from a deposit related to an adjacent possible pot *tanur* (bread oven, context 337) and may contain the rake out from an episode of use of that *tanur*. The *tanur* itself produced a sample with only very limited remains (the sample was not sorted), including a small seeded legume and a *Capsicum* sp. seed, but no cereal remains. The *tanur* fill therefore provides no clues as to the relationship between these two samples. The significance of sample 03PF/105 in terms of its evidence for fuel use is discussed below. This sample produced a very recent date however, and the possibility that this has derived from more recent material has been raised (chapter 4).

6.2.2 Composition of Desiccated Samples

Samples containing desiccated remains were recovered from phases 1 to 5, although were generally restricted to phases 1 to 3. The samples which produced desiccated material were taken from spreads or room fills, two of which are identified as external areas (02CF/047 and 03CF/046), while the remainder are thought to be internal, and one phase 4 pit fill (04PF/107). Leaves tended to dominate samples from phase 1 to 3 so obscured the proportions of other categories of remains in the samples. Figures 6.6 and 6.7 illustrate the composition of desiccated assemblages both including and excluding the leaves. The high number of leaves in the samples is likely to be in part a product of preservation, although leaves were also common in some of the phase 1 to 3 charred assemblages, and both charred and desiccated leaves were present in sample 03CF/046. It would seem likely, therefore, that this pattern reflects depositional activities or conditions during the later occupation at the site. The other characteristic of the desiccated assemblages is the high number of items. Eight of the ten samples illustrated produced over 300 desiccated items and six produced over 500.

With the exception of pit fill sample 04PF/107, chaff forms a significant component of the desiccated samples. The proportion of weeds was variable, while grain was very rare with the exception of one small phase 5 sample (05RF/401). Fruit remains are significantly less dominant than in the charred deposits. In part this is due to the increased dominance of chaff, although fruits were present in lower numbers. It is not clear if this is due to preservation conditions (fruit possibly surviving as desiccated remains less well than charred) or if it is a reflection of depositional activities. Where fruit is dominant in the charred phase 3 samples the overall number of items in those samples is low. It would appear therefore that fruits are less well represented in phases 1-3 than earlier and consequently are less dominant in the desiccated samples. There would appear therefore to be a pattern of fewer fruit remains and increased chaff in the later and particularly the desiccated samples. Sample 04PF/107 is significantly different to the other samples in that it consists of over 90% weed seeds. Generally however, the desiccated samples are dominated by weeds and cereal chaff, with limited fruit and very few cereal grains. The very high proportions of chaff and low grain count must be in part due to preservation. The significance of chaff in general is discussed in more detail below (section 6.4 and 6.7).

6.3 Common Taxa by Absolute Count and Ubiquity

The relative importance of individual taxa is difficult to determine given biases due to seed production, use of the plant, treatment of the plant or preservation biases. However, it is useful to look for taxa which appear in large numbers in individual samples or phases and ubiquity of species (the percentage of samples in which they occur). It might be assumed for example, that a particular economic species which occurs in a large number of samples, although not necessarily in large numbers, is used on a routine or regular basis. Alternatively, where one particular taxon appears in large numbers dominating one particular sample, the assemblage might be assumed to be relatively pure, possibly representing a stored product. The absolute counts for each taxa overall and in each phase, and the ubiquity for each taxon were calculated. Counts and ubiquity for desiccated and charred samples are given separately.

Tables 6.1 and 6.2 show the top ten/eleven most numerous and ubiquitous taxa preserved by charring. Taxa/plant parts present in both tables are indicated by highlighting in bold. The most ubiquitous taxa include more than one item of equal presence so eleven items are listed. Percentage ubiquity is calculated as the number of samples an item is present in out of 64 samples in total. Indeterminate weed seeds were not included in the calculations as they represent several species.

Table 6.1 Ten most numerous charred plant items recorded from all samples

Taxon	Plant Part	Total Count
Hordeum vulgare	**rachis**	**1594**
Phoenix dactylifera	**stone**	**1382**
Ficus carica	**seed**	**1369**
Cerealia indet.	rachis	775
Pennisetum glaucum	**grain**	**558**
Triticum aestivum/durum	**rachis**	**553**
Cereal size	culm nodes	390
Hordeum vulgare	**grain**	**383**
Vitis vinifera	**seed**	**356**
Fabaceae indet.	small seed	193

Table 6.2 Most ubiquitous plant items preserved by charring from all samples

Taxon	Plant Part	samples present	% ubiquity	total count
Phoenix dactylifera	**date stone**	**61**	**95.31**	**1382**
Hordeum vulgare	**grain**	**48**	**75**	**383**
Vitis vinifera	**seed**	**48**	**75**	**356**
Hordeum vulgare	**rachis**	**45**	**70.31**	**1594**
Cerealia indet.	grain	44	68.75	161
Ficus carica	**seed**	**42**	**65.63**	**1369**
Phoenix dactylifera	perianth	37	57.81	173
Poaceae	small seeded	36	56.25	160
Phalaris sp.	caryopses	31	48.44	95
Pennisetum glaucum	**grain**	**28**	**43.75**	**558**
Triticum aestivum/durum	**rachis**	**28**	**43.75**	**553**

There is a broad correlation between the two lists: seven taxa/plant parts occur in both: *Triticum aestivum/durum* and *Hordeum vulgare* rachis, *Hordeum vulgare* and *Pennisetum glaucum* grain, and seeds of *Phoenix dactylifera*, *Ficus carica* and *Vitis vinifera*. The absence of *Triticum* sp. grain is of interest given the presence of *Triticum* chaff and of *Hordeum vulgare* grain, suggesting that while *Triticum* chaff was commonly brought into the site its grain may have entered the deposits less frequently than that of *Hordeum vulgare*, possibly suggesting different uses of the two grain types.

There are also some significant discrepancies between the two lists. Small seeds of indeterminate Fabaceae appear in the ten most numerous items, but not in the most ubiquitous, although they do appear fairly commonly (19 of 64 samples). These were particularly concentrated in two samples (07CF/549 and 03PF/105), both of which also contained numerous seeds of *Alhagi* type or in the case of sample 03PF/105, pods and seeds of *Alhagi* sp. In both cases it is likely that the seeds and pods are all of the same species. Both samples also produced large quantities of cereal chaff while sample 03PF/105 also produced frequent seeds of *Portulaca oleracea.* Sample 07CF/549 produced large quantities of the utricles of *Cornulaca monacantha* and the unidentified seed capsules Jarma Type V. Fabaceae seeds also appear in notable numbers as desiccated remains associated with pods of *Alhagi* sp., and *Portulaca oleracea* in 04PF/107. It is likely that these particular species are of some significance although they are concentrated in a limited number of samples.

Finally small-seeded grasses and seeds of *Phalaris* sp. were present in approximately 50% of samples, but generally in low numbers. The grasses clearly may include a range of species but this never-the-less demonstrates the ubiquity of grasses amongst the weed flora. The ubiquity of *Phalaris* may be associated with its deliberate collection or tolerance as an impurity of the cereal crops. The general ubiquity of grass seeds as both charred and desiccated remains is of interest and may be related to the use of grasses as animal or human feed or simply the local flora.

Tables 6.3 and 6.4 show the ten/twelve most numerous desiccated plant types (taxon and plant part) by total count and by ubiquity. Ubiquity is shown as the percentage of samples a taxon is present in out of the 35 samples in which desiccated remains are present and out of the total of 64 samples. Several taxa were present in equal numbers of samples, therefore the twelve most ubiquitous are shown rather than ten. The six taxa highlighted in bold occur in both lists and can be assumed to represent abundant taxa. As with the charred remains cereal chaff is most notable of these items, particularly *Pennisetum glaucum* involucres, *Hordeum vulgare* and free-threshing *Triticum* rachis (*Triticum aestivum* and *T. aestivum/durum*). *Pennisetum glaucum* and *Sorghum bicolor* chaff were rarely represented as charred remains and their abundance/ubiquity as desiccated remains must be related to preservation, the chaff being comparatively fragile compared to *Hordeum vulgare* and *Triticum* sp. and therefore less likely to survive charring. *Tamarix* sp. leaves are also numerous. *Tamarix* sp. trees are common growing on the edges of arable plots in the area and the branches are frequently cut and used as fencing or wind breaks today. The trees produce numerous small leaves and it is unsurprising that they are well represented in the samples.

Table 6.3 Ten most numerous desiccated plant items by count

Taxon	Plant Part	Total Count
Tamarix sp.	**stem frags./Leaves**	**1490**
Portulaca oleracea	seed	913
Pennisetum glaucum	**involucre**	**890**
Hordeum vulgare	**rachis**	**404**
Sorghum bicolor var *durra*	spikelet	220
Triticum aestivum	**rachis**	**133**
Cerealia indet.	**rachis**	**131**
Myriophullym/Zylophyllum	stem fragments	125
Triticum aestivum/durum	**rachis**	**93**
Capsicum sp.	seed	90

Table 6.4.Most ubiquitous desiccated plant items

Taxon	Plant Part	samples present	% ubiquity of 64	% ubiquity of 35	count
Hordeum vulgare	**rachis**	**20**	**31.25**	**57.14**	**404**
Cerealia indet.	**rachis**	**16**	**25**	**45.71**	**131**
Triticum aestivum	**rachis**	**12**	**18.75**	**34.29**	**133**
Setaria/Brachiaria type	caryopses	12	18.75	34.29	47
Triticum aestivum/durum	**rachis**	**11**	**17.19**	**31.43**	**93**
Phoenix dactylifera	stone	10	15.63	28.57	52
Hordeum vulgare	grain	9	14.06	25.71	26
Pennisetum glaucum	**involucre**	**8**	**12.5**	**22.86**	**890**
Cerealia indet.	culm nodes, large	8	12.5	22.86	30
Phoenix dactylifera	perianth	8	12.5	22.86	30
Tamarix sp.	**stem frags./Leaves**	**8**	**12.5**	**22.86**	**1490**
Phalaris sp.	caryopses/glumes	8	12.5	22.86	47

There are also some discrepancies between the two lists. Three significant species are well represented in terms of number but occurred in relatively few samples: *Portulaca oleracea* and *Capsicum* sp. seeds (each present in 7 samples only) and *Sorghum bicolor* var *durra* spikelets (present in 4 samples). *Portulaca oleracea* is particularly numerous in three samples (01S/003, 03CF/046 and 04PF/107) where it would seem plausible that the plants, which are used as a vegetable, were deliberately collected and deposited. Sample 01S/003 also produced abundant chaff, *Tamarix* sp leaves and fairly frequent seeds of *Capsicum* sp. (pepper/chilli). Sample 03CF/046 also produced abundant chaff, especially of *Sorghum bicolor* and *Pennisetum glaucum*, and frequent assorted leaves, thorns or stem fragments. Sample 04PF/107 produced only limited chaff, some fruit (particularly *Vitis vinifera*), frequent seeds and pods of *Alhagi* sp. and abundant sheep/goat droppings, many of which contained seeds of *Portulaca oleracea*. This third sample certainly raises the possibility of *P. oleracea* and *Alhagi* sp. being deliberately collected as an animal fodder, possibly implying by association that the various leaves and thorns were also derived from material brought into the site for animal fodder and/or bedding (see below, section 6.7.2 for a discussion on fodder). Seeds of the *Capsicum* species occur in fairly large numbers in individual fruits, so large quantities of seeds in individual samples may be derived from few fruits.

The list of most ubiquitous taxa suggests that there are some taxa/plant parts which are persistently present but in small quantities. In part this is likely to be a product of preservation and/or sampling. This list includes caryopses of *Setaria/Brachiaria* type and *Phalaris* sp. as well as grain of *Hordeum vulgare*. As has been noted already grasses, including cereals, appear to be poorly represented as desiccated remains, and it is therefore likely that while they are present in large numbers of samples (as suggested by charred assemblages) their poor preservation results in only few seeds being counted. The stones and perianths of *Phoenix dactylifera* were present in 28.5% of samples, but in relatively low numbers. This may be due to their relatively large size, and the fact that sampling was biased towards the more numerous smaller seeded items.

6.4 Identifying Crop Processing Activities: Cereals

As discussed in Chapter 3, analogous models of crop processing based on ethnographic data are useful when attempting to reconstruct past crop processing activities. The basic stages and mechanics of crop processing are determined by the physical properties of the crops themselves. In the current study the internal composition of individual samples is examined by using a range of ratios including chaff to grain, small to large weed seeds and grain to weeds, (after Van der Veen and Jones 2006 and Hillman 1981; 1984) as a method of identifying crop processing stages represented at the site.

With the exception of *Triticum dicoccum* (emmer wheat), which is present in very small quantities in five samples only (a total of one grain and eight glume bases), the cereal crops represented at Jarma are free-threshing varieties. In free-threshing cereals the grain is easily released from the rachis or glumes thus reducing the number of processing stages necessary to prepare clean grain. While *Pennisetum glaucum* and *Sorghum bicolor* are processed in slightly different ways, the basic stages are the same. The basic stages of cereal processing (for wheat and barley in particular but applicable to all cereals) are displayed in table 6.5.

Table 6.5: The basic stages of cereal processing and resulting by products (after Hillman1984):

Processing Stage	Purpose	Product	By-Product
Harvesting	to bring the crops in from the fields, by cutting or pulling	Ears, straw, weeds (and roots). Straw length/weed height/presence of roots dependant on harvesting method.	
Threshing (and raking)	to release the grain from the chaff and straw	Grain, fine chaff, some broken straw, some rachis, weed heads and seeds	Coarser straw, rachis and awns, coarse weeds
Winnowing	to separate the grain from the light chaff	Grain, heavy straw nodes, some rachis, most weed seeds	Light chaff, long straw frags., lightest weed seeds/seed heads, some rachis, most awns
Coarse Sieving	to separate the grain from the heavy/large chaff and weed seeds	Grain, occasional rachis + awn frags., weed seeds (passes through sieve)	Most remaining straw and rachis and weed seed heads (retained in sieve)
Fine Sieving	to separate the grain from the smaller chaff and weeds	Grain, grain sized weed seeds, rare rachis (retained in sieve)	Weed seeds smaller than grain, small rachis and awn frags.

The glumed wheats (emmer, spelt and einkorn) and some millets produce grains which are tightly held within their glumes and require additional stages of processing to release them (pounding, 2nd winnowing, 2nd coarse sieving, fine sieving). These stages are usually carried out after coarse sieving and are often carried out on a piecemeal basis immediately prior to use, although may be conducted prior to storage. Much discussion of consumer/producer sites in Britain is based on hulled wheats where these final stages are more likely to take place within the settlement. The processing of free-threshing cereals in warm or hot climates is more likely to take place entirely in the field, with the exception of cleaning by hand picking which might take place immediately prior to milling or storage. The presence of processing waste would therefore indicate it was deliberately brought into the site and is usually interpreted as indicating local cultivation.

The harvesting and processing of the large millets (*Pennisetum glaucum* and *Sorghum bicolor*) varies slightly from that of wheat and barley, primarily as a result of difference in the method of harvesting. A detailed ethnographic study of millet harvesting and processing in Andhra Pradesh and Gujarat, India was conducted by S. Reddy (1994; 1997). *Pennisetum glaucum* and *Sorghum bicolor* (and *Eleusine* sp.) produce tall thick straw, with large compact panicles (seed heads), which can only be cut up to three plants at a time. Harvesting therefore tends to involve cutting the panicles only, or cutting one to three plants lower down the straw but removing the panicles immediately after harvest. Both methods tend to leave the straw in or by the field, reduce the quantity of weeds incorporated with the harvest to negligible quantities, and result in the panicles only going on to further processing stages. Subsequent processing stages are therefore more limited and less time consuming than for wheat or barley, or for the small millet crops (*Setaria* spp., *Panicum miliare = P. sumatrense*, little millet). Both harvesting methods tend to produce far fewer weeds than harvesting of other cereal crops. Reddy also notes two types of winnowing: winnowing by wind or winnowing by shaking (Reddy 1997, 170) which is used for the small seeded millets which would be lost if winnowed by wind. If a *Pennisetum glaucum* or *Sorghum bicolor* crop product is associated with weed seeds in an archaeobotanical sample it can be assumed that it was harvested by cutting lower on the straw, while if weeds are absent it might imply harvesting of the panicle only. The other processing stages, threshing, winnowing and sieving will result in essentially similar components as for wheat and barley regardless of winnowing method, but always with fewer weed seeds.

The various ratios which were applied to the archaeobotanical data are detailed in table 6.6 (after Van der Veen and Jones 2006). Ratios of rachis to grain, culm nodes to grain, weeds to grain and small weed seeds to large weed seeds will be affected by the various processing stages and so should be visible in the archaeobotanical data, taking into account preservation biases, particularly charring which tends to bias in favour of grains over chaff (Boardman and Jones 1990). High or low values of each ratio would indicate the presence of the product and/or waste product of the various processing stages. In practice if multiple processing stages are conducted in the same location the waste product is likely to be combined. For free-threshing cereals processed outside on the threshing floor (as opposed to in a threshing barn for example) we would expect to find threshing/winnowing waste and probably coarse sieving to be combined. Fine sieving might be conducted at the threshing floor or at a later stage prior to use/storage. The density of crop remains per litre deposit will provide an indication of deposition rate (Jones 1991). A high density will suggest rapid (deliberate) deposition or storage, while a low density would suggest piecemeal deposition over a period of time for example mixed with other daily refuse.

Table 6.6: Ratios applied to the data (adapted from Van der Veen and Jones 2006)

Sample variable (ratio)	Sample Origin	
	High Value	Low value
Rachis internodes/grain	By-product from early processing stage	Grain product
Involucre or spikelet base/grain	By-product from early processing stage	Grain product
Culm nodes/grain	By-product from early processing stage	Grain product
Weed seeds/cereal grain	By-product from late processing stage/fine sieving	Grain product
Small/large weed seeds	By-product from fine sieving	Product from sieving or by-product of hand cleaning
Number of crop items per litre deposit	Rapid/single deposition	Slow/repeated deposition

6.4.1 The number of rachis internodes to grains

Given the difficulties of identification of free-threshing *Triticum* grain to species all free-threshing wheats were combined. The indeterminate *Hordeum/Triticum* rachis was then assigned to either *Hordeu*m or *Triticum aestivum/durum* according to the ratio of the identified rachis. Indeterminate cereal grain was assigned according to the ratios of identified grain species for each sample or in the case of the desiccated remains the total species count. Unidentified desiccated grain was only present in one sample in which none were identified to species. The 14 grains were therefore divided between the three species identified according to their over all ratios in the combined samples. Given the paucity of *Triticum dicoccum*, indeterminate *Triticum* grain is assigned with *Triticum aestivum/durum* and the ratio of *T. dicoccum* grain to glume bases is not attempted.

The ratio of rachis to grain was calculated for *Triticum aestivum/durum* (including *Triticum* Type X) and *Hordeum vulgare*. The ratio of rachis to grain in six-row *Hordeum vulgare* is 1:3, or 0.3 (three grains per rachis), hence a ratio of more than 0.3 would indicate the presence of early processing residues (threshing/winnowing/ coarse sieving waste), or less than 0.3 would indicate more fully processed grain (or preservation bias due to destruction of chaff through charring). In the free-threshing *Triticum* species the ratio of rachis to grain is 1:2-6 (i.e. one rachis to two to six grains), therefore anything significantly less than 0.17 would indicate a grain rich deposit, while anything significantly greater than 0.5 would indicate a rachis-rich deposit and consequently the presence of the early stage of crop processing.

6.4.1.1 Charred assemblages

A total of 54 samples produced charred grain and/or rachis of *Hordeum vulgare*. Rachis outnumbered grain in 27 samples while grain outnumbered rachis in 21 samples. Only 12 samples produced a ratio of 0.3 or less. However all 12 samples with low ratios produced only very few grains (a maximum of 20 grains in sample 03F/367, usually 1 – 5 grains). It is therefore likely that poor preservation has affected the ratios of these samples and they can not be regarded as reliable. A total of 37 samples produced ratios of greater than 0.3 while a further six produced rachis only. Again the number of rachis or grain present in some of these samples was low. Of the 14 samples which contained more than 30 items (Table 6.7), all produced a ratio of rachis to grain indicative of the waste of early processing stages. This is particularly so when it is considered that charring biases grain rather than rachis which tends to survive less well (Boardman and Jones 1990). The grain present in these samples may derive from immature grain which did not separate from the rachis or may represent grain which entered the deposit via a separate processing route.

A total of 37 samples produced rachis and/or grain of free-threshing *Triticum* sp. (*Triticum aestivum/durum*). However, only five of those samples produced more than 30 items of *Triticum aestivum/durum*, all of which contained significantly more rachis than grain. (The number of items in the remaining samples was considerably less than 30). The ratios for all samples with more than 30 items of grain and rachis are listed below:

Table 6.7 The ratio of rachis to grain for both barley and free-threshing wheat.

Hordeum vulgare rachis:grain		**Triticum aestivum/durum**	
01S/022	**79:1 = 79.0**	**01S/022**	**132:1 = 132**
03PF/106	**55:10 = 5.5**	**03PF/106**	**196:1 = 196**
03F/102	31:21 = 1.5	03PF/105	270:7 = 38.57
03RF/108	45:3 = 15.0	**04I/128**	**167:8 = 20.88**
04I/128	**532:27 = 19.7**	05S/415	45:2 = 22.5
05F/389	315:1 = 315.0		
05S/382	53:35 = 1.5		
05S/385	26:14 = 1.9		
05S/411	59:7 = 8.4		
06F/534	80:13 = 6.2		
06F/400	264:12 = 22.0		
06F/513	35:20 = 1.8		
07CF/549	253:29 = 8.7		
07S/592	47:8 = 5.9		

While no samples can be said to be grain rich, several are clearly rachis rich, some strikingly so (e.g. 05F/389). Of those three samples are rich in both *Triticum* and *Hordeum vulgare* rachis, samples 01S/022, 03PF/106 and 04I/128 (highlighted in bold). Rachis rich samples occurred in phases 1 and 3 to 7. No charred remains were recovered from phase 2 and the earlier phases produced only small numbers of cereal remains. There does not, therefore, seem to be any obvious changes in the presence of early crop processing stages throughout the history of the site based on the ratios of rachis to grain. There may be less use of *Triticum* rachis in the earlier deposits, however the paucity of remains does not allow for any conclusion to be made concerning *Triticum* chaff in these early deposits. There is no evidence for the presence of large charred deposits of processed grain in any phase.

6.4.1.2 Desiccated Assemblages

A total of 17 samples produced desiccated rachis of *Triticum aestivum/durum*. None contained desiccated grain. While the majority of samples produced only occasional remains three samples produced more than 30 rachis segments: 01S/003 (83), 01S/004 (87), and 03CF/046 (42). A fourth sample, 1/2S/048 produced 26 rachis segments. Desiccated remains of *Hordeum vulgare* were identified in 21 samples. Only one sample produced a ratio of less than 0.3 (0), while one more produced a ratio of 1. These samples produced only few items however so cannot be considered reliable. Of the 19 samples which produce more rachis than grain, four produced more than 25 items: 01S/003 (rachis to grain = 27:9), 1/2S/048 (61:0), 03CF/046 (22:5) and 05F/366 (274: 0). Sample 05F/366 in particular clearly contains a deposit of *Hordeum vulgare* processing waste.

Desiccation appears to favour rachis over grain. However, even taking into account preservation biases it is clear that quantities of the waste from early stages of processing (predominantly rachis) had been brought into the site. Three samples produced processing waste for both *Triticum aestivum/durum* and *Hordeum vulgare*: **01S/003, 1/2S/048 and 03CF/046.**

6.4.2 *Sorghum bicolor* and *Pennisetum glaucum* chaff to grain

The number of charred *Sorghum bicolor* grains is too low to be meaningful so ratios of grain to spikelets were not calculated. While the number of charred *Pennisetum glaucum* grains was much greater the number of chaff items was very limited. Only two involucres and 6 spikelets were identified. The charred *Pennisetum glaucum* remains would therefore appear to suggest processed grain was represented in the samples. In the majority of samples the number of grains was low, however, with only three samples producing more than 25 grains: 03PF/106 (341), 05S/410 (28) and 09F/599 (27). Perhaps the number of grains is only really significant in sample 03PF/106. Given the fragility of *Pennisetum glaucum* chaff it is not possible to draw any conclusions concerning the taxonomic processes represented. Sample 03PF/106 contained a large number of *Pennisetum glaucum* grains as well as evidence for the early stages of crop processing of both *Triticum aestivum/durum* and *Hordeum vulgare*. It is possible that the small size of the *Pennisetum glaucum* grain is of relevance here (sample 03PF/106 included a large number of small grain), in that small grain may have been removed from the prime grain by fine sieving and therefore represents processing waste. Alternatively small immature grain which did not fall loose of the panicles may have entered the deposits, the panicles themselves having been destroyed by burning.

Desiccated remains of *Pennisetum glaucum* were present in nine samples. Where whole segments of the ear were present they were assigned 100 involucres for the purposes of the numerical analysis. While this is not accurate it is likely to be an underestimation so will favour grain rather than chaff. As ear segments only occurred in samples with large quantities of *Pennisetum glaucum* chaff it is not likely to affect the out-come in an unrealistic direction. Grain outnumbered involucres in only one sample, although the numbers involved were very low (7 grain). Six samples produced more than 25 items, and in all involucres significantly outnumbered grain. These include two samples (1/2S/048 and 03CF/046) which contained segments of *Pennisetum glaucum* ear. In each case grain was absent from the ear segments, although the ears had remained largely intact. It was not possible to establish if these ears represented immature or infertile crop. Regardless of the fertility of the crop, the ratios of involucres to grain indicate that the processing waste was brought into the site independent of the grain.

Desiccated *Sorghum bicolor* remains were present in five samples only. Of those only one produced more than 25 items (03CF/046). This sample was rich in spikelets (189 to 3 grains), thus suggesting the presence of processing waste in the sample. A summary of the ratios for desiccated *Pennisetum glaucum* and *Sorghum bicolor* chaff to grain is shown below (all samples containing *Sorghum bicolor* are included):

Table 6.8 The ratio of pearl millet and sorghum chaff to grain.

***Pennisetum glaucum* involucres to grain**			***Sorghum bicolor* spikelets to grain**		
01S/003	87:4	= 21.75	01S/003	23:1	= 23
01S/004	32:4	= 8	01S/004	5:0	-
01S/022	23:2	= 11.5	02CF/047	3:0	-
02CF/047	172:3	= 57.33333	03CF/046	189:3	= 63
1/2S/048	307:7	= 43.85714	05RF/401	0:1	-
03CF/046	267:7	= 38.14286			

6.4.3 Culm nodes to grain

Charred culm nodes were present in 26 samples. A further 32 samples produced grain but no culm nodes. Of those 26 samples with culm nodes four samples produced ratios greater than one (i.e. culm nodes out number grain). Of those four, two samples (05F/389 and 05S/393) produced only small numbers of items (nine culm nodes to one grain and two culm nodes to one grain), and the ratios can not be taken as reliable. The remaining two samples (04I/128 and 07S/592) produced much larger numbers of items. These samples can therefore be argued to contain early stages of crop processing and suggest the presence of straw.

Table 6.9 The ratio of culm nodes to cereal grain in samples with over 30 items.

Sample	Culm node: total grain
04I/128	186:57 = 3.263158
07S/592	51:8 = 6.375

Sample 04I/128 also produced 41 root nodes, as well as large quantities of *Triticum* X type and *Hordeum vulgare* rachis. It is therefore suggested that this sample contained crops which had been harvested, or at least cleared, by uprooting, and whole lengths of straw.

The remaining samples produced ratios less than one, i.e. grain outnumbered culm nodes. Of those 14 samples produced more than 25 items. However, it remains difficult to argue for the absence of straw given the differential survival rates of grain and straw. Sample 03PF/106 produced a large assemblage with 50 culm nodes and some 352 grain. The grain in this sample is predominantly of *Pennisetum glaucum* however, for which the chaff: grain ratio suggests a processed crop (although preservation biases strongly favour grain over chaff for this crop). If the *Pennisetum glaucum* grains are excluded the ratio of culm nodes to grain is 50:11 (4.5) which would indicate the presence of early processing stages and straw. Whether the culm nodes are derived from a *Pennisetum* or *Hordeum/Triticum* crop, straw fragments were clearly present in the deposit and therefore indicate that the early stages of processing are represented. In other words this is a mixed sample. The use of culm nodes is clearly not a reliable indicator of early processing stages *per se*, but it is useful as an indicator of the presence of straw.

Desiccated culm nodes were present in eight samples, while a further four samples produced grain but no culm nodes. Only one sample produced a positive ratio (01S/004 - 7 culm nodes to 5 grain, ratio of 1.4), and the numbers involved are too small to be reliable. Two further samples produced culm nodes and no grain. All the other samples were grain rich, but in numbers too small to be significant (less than 25). This paucity of culm nodes is of interest in terms of preservation in that it suggests the absence or paucity of culm nodes or straw in these samples is genuine and not merely a product of preservation. Given the frequent rachis in some samples it is therefore suggested that the rachis ears are represented rather than whole straw with rachis attached. Possibly this reflects a change in the use of cereal chaff in the later occupation at the site. If *Pennisetum* and *Sorghum* chaff were used in preference to *Hordeum* and *Triticum* (possibly because it was cultivated more widely or because of differential use) then the panicles, which tend to be separated from the straw at an early stage might enter the site without the straw, whereas *Hordeum* and *Triticum* rachis and straw are more likely to remain together. However, the ratio of desiccated *Hordeum* **and** *Triticum* chaff combined to *Pennisetum* and *Sorghum* chaff combined (Table 6.10) demonstrates that the millets do not dominate the chaff element of all the desiccated samples. It is possible therefore that in the upper deposits at least straw was separated from rachis and panicles of all crops after harvest and used separately. This might be the result of harvesting methods (harvesting high on the straw) or it might be a reflection of differential use of straw and chaff resulting in the straw only occasionally entering the site.

Table 6.10 The ratio of desiccated barley/wheat rachis to 'millet' chaff.

Sample	*Hordeum+Triticum*: *Pennisetum+Sorghum*
01S/003	110:110 = 1
01S/004	99:37 = 2.7
01S/022	5:23 = 0.09
02CF/047	25:175 = 0.14
1/2S/048	87:307 = 0.28
03CF/046	64:456 = 0.14
05F/363	**276:0 = -**

6.4.4 Number of weed seeds to grain and small to large weed seeds.

High and low values for these ratios are given as greater than 2 (i.e. twice as many weed as grain or small seeds as large seeds) or less than 0.5, while anything between 2 and 0.5 is regarded as inconclusive or mixed. These figures are rather arbitrary so it is noted when figures are significantly higher and therefore more conclusive. As with any archaeobotanical data the affects of charring cannot always be measured so any results based on ratios must take appropriate biases into account. Given the difficulties of assigning weed seeds to species or even genus in the Jarma material it was decided to examine weed seeds using the physical characteristic of the archaeobotanical material rather than use the characteristics of modern comparative material. In practice this limits assignment of weed seeds to size, or to headedness when seeds are obviously still retained in capsules or seed heads. As charring tends to cause some shrinkage of material there is likely to be a bias towards small seeds. In practice the difference between large and small seeds was generally clear, small seeds usually being less than 2mm in length or diameter, and more frequently around 1mm. Weed seeds which were still retained in their capsules, such as the *Haplophyllum* sp. were counted as seed heads and classified as large, omitting the number of weed seeds which are believed to have come loose after deposition. Indeterminate weed seeds were classified by size as small if less than 2mm, indeterminate if damaged but not obviously bigger than 2.5mm and large if bigger than 2.5mm. Where size was unclear due to severe damage the seed was omitted.

Of those samples which contained more than 30 classified weed seeds 19 produced more small than large weed seeds (see table 6.11). Sixteen samples had at least twice as many small as large seeds, while 11 samples contained small weed seeds numbering at least 5 times that of large seeds. Of those samples in which large seeds outnumbered small seeds or large and small seeds were present in equal numbers, the total number of weed seeds was always less than 25 and cannot be regarded as reliable. The presence of small weed seeds therefore tends to dominate the weed assemblages, usually interpreted as indicative of the presence of fine sieving waste. Alternatively the weed seeds might include species which did not enter the samples as cereal processing waste.

Table 6.11 Ratio of charred small to big weeds and weed seeds to grain, showing only those samples where the total weeds or total of weeds and grain is more than 30.

Sample	small weeds:big weeds	weeds:grain
01S/022	39:26 = 1.50	65:15 = 4.33
03PF/106	106:17 = 6.24	123:352 = 0.35
03F/102	-	23:21 = 1.10
03PF/105	288:123 = 2.34	411:27 = 15.22
03RF/108	51:2 = 25.50	53:4 = 13.25
04S/104	-	21:14 = 1.50
04RF/121	-	13:14 = 0.93
04CF/129	48:16 = 3.00	64:39 = 1.64
04I/128	217:46 = 4.72	263:57 = 4.61
04F/383	-	16:16 = 1.00
05PF/361	-	16:28 = 0.57
05F/363	-	23:10 = 2.30
05F/366	35:6 = 5.83	41:28 = 1.46
05F/389	39:1 = 39.00	40:1 = 40.00
05RF/401	31:4 = 7.75	35:6 = 5.83
05S/382	52:21 = 2.48	73:60 = 1.22
05S/385	43:6 = 7.17	49:17 = 2.88
05S/387	-	18:8 = 2.25
05S/390	85:8 = 10.63	93:80 = 1.16
05S/408	-	20:10 = 2.00
05S/410	153:8 = 19.13	161:29 = 5.55
05S/411	87:10 = 8.70	97:10 = 9.70
06F/400	58:9 = 6.44	67:14 = 4.79
06F/513	30:15 = 2.00	45:22 = 2.05
06F/534	28:7 = 4.00	35:28 = 1.25
6/7PF551	-	13:13 = 1.00
07CF/549	245:181 = 1.35	426:38 = 11.21
07S/592	57:8 = 7.13	65:8 = 8.13
09F/599	-	1:27 = 0.04

Weed seeds outnumbered cereal grain in 58 samples of which 28 produced a combined total of grain and weeds greater than 25. Of these, 15 samples produced at least twice as many weed seeds as grain, and eight produced at least five times as many weeds as grain (03PF/105, 03RF/108, 05F/389, 05RF/401, 05S/410, 05S/411, 07CF/549, and 07S/592). Cereal grain out numbered weed seeds in 16 samples, of which only four produced a combined total of grain and weeds greater than 25 (03PF/106, 04RF/121, 05PF/361and 09F/599). In the case of sample 03PF/106, while the number of grains do outnumber weeds significantly (giving a ratio of 0.35) the number of weed seeds is still fairly high (352 grains to 123 weed seeds), and of those most are small seeded. This sample may contain unsieved grain or a mixture of grain and fine sieving waste. Sample 09F/599 produced 27 grain, all of which were of *Pennisetum glaucum*, and a single weed seed.

This sample may therefore represent clean (sieved) grain. The apparent purity of this sample may also be the result of the nature of this crop and the harvesting method. Samples 04RF/121 and 05PF/361 produced grain and weeds in much more equal numbers. Four samples produced grain and weeds in equal number, of which two contained at least 25 items (04F/383 and 6/7PF551). These samples with equal or similar numbers of grain and weed may represent mixed deposits or unsieved grain.

Given the different harvesting methods of the millets (*Pennisetum glaucum* and *Sorghum*) and the winter cereals, the former tending to result in very few weeds being harvested, the weed seed/grain ratio was re-calculated omitting the millets. This resulted in three samples being re-classified and three samples producing void ratios. Sample 03PF/106 which had been classified as a grain product on the basis of weed seeds/all grain, was re-classified as a sieving by-product with a ratio of 11.18 (123 weeds to 11 grain). Assuming the weeds are associated with the *Triticum* and/or *Hordeum* crop this would imply that this sample contains a clean *Pennisetum glaucum* product and waste from a *Triticum/Hordeum* crop (as suggested by the chaff to grain ratios above). The *Pennisetum glaucum* grain may also be tail grain discarded with processing waste rather than prime grain. Alternatively this sample may indicate a mixture of products and by-products and the weed seeds may not be the product of arable waste at all. Samples 04CF/129 and 06F/534 produced a higher value with weeds more obviously numerous than grain so were re-classified as fine-sieving by-products rather than 'mixed'. Samples 04S/104, 6/7PF55 and 109F/599 produced void ratios, the grain component in each consisting entirely of *Pennisetum glaucum*.

Eight samples produced desiccated weed seeds. One sample produced only 24 weed seeds, while the rest produced more than 25. In all cases small weeds outnumbered large weed seeds, generally significantly so, and all were classified as the by-product from fine-sieving. The ratio of weeds to grain produced similar results with all samples being rich in weed seeds in relation to grain, and therefore classified as the by-product from sieving. Three samples produced no grain. Desiccation seems to produce a bias against cereal grains. The small to large weed seed ratio however would indicate that the dominance of sieving waste is real.

Table 6.12 Ratios of small/large weed seeds and weeds/grain for desiccated samples

	small weeds: big weeds	all weeds:grain	weed seeds:non-millet grain
01S/003	1742:4 = 35.5	146:14 = 10.4	146:9 = 16.2
01S/004	48:8 = 6	56:5 = 11.2	56:1 = 56
01S/022	42:5 = 8.4	47:3 = 15.7	47:1 = 47
02CF/047	43:5 = 8.6	48:5 = 9.6	48:2 = 24
1/2S/048	16:8 = 2	24:7 = 3.4	24:0 = -
03CF/046	147:6 = 24.5	153:15 = 10.2	153:5 = 30.6
04PF/107	629:82 = 7.7	711:0 = -	711:0 = -
05F/366	35:0 = -	35:0 = -	35:0 = -

6.4.5 Density of crop product (crop items/litre deposit)

Density of crop product was calculated as grain and chaff per litre deposit, and also grain, chaff and weeds per litre deposit, the second density assuming that the weed seeds entered the deposits with the cereal products. In all cases the densities were relatively low. No one charred deposit appeared to contain a pure deposit of burnt stored grain for example or a deliberate dump of crop processing waste. This was fairly evident from the overall composition of the samples which tended to contain mixtures of cereal and other crop products. Some samples did produce denser deposits of crop products than others which might be a result of depositional processes, such as the concentrated use of crop material for animal bedding/food or even for fuel. Sample 04PF/107 produced a particularly dense concentration of remains all of which are weed seeds. In this case it is not possible to associate the weeds with cereal processing waste given the absence of cereal products and chaff in the sample. Clearly this sample represents some thing different involving wild or weed species.

The samples with more than 100 items per litre are listed below. Desiccated remains can be seen to be present in slightly, although not greatly denser concentrations than charred remains. The total number of desiccated cereal products overall is much higher than the total charred items per litre (given below for all samples). This does tend to indicate the greater density of desiccated remains over all in comparison to charred which is clearly a product of preservation.

Table 6.13 Density of crop items (items/litre) for all samples which produced more than 100 items per litre including weeds. Total is for all samples including those with fewer than 100 items per litre.

	cereal products per litre	cereal products including weeds per litre
Desiccated samples		
01S/004	74.0	102.0
02CF/047	103.5	127.5
03CF/046	104.2	134.8
04PF/107	0.0	177.8
Total for all samples	41.2	68.5
Charred samples		
01S/022	120.0	152.5
04I/128	94.3	121.1
05F/389	98.0	109.7
Total for all samples	14.1	22.5

6.4.6 The Presence of Light Chaff

Desiccated samples in particular also contain large quantities of free-threshing *Triticum* glume bases and awn fragments. These elements of light chaff are difficult to quantify, particularly as they are often very fragmentary, although it is useful to note their presence. They were particularly numerous in six samples detailed below. The two samples in phase 6 produced no other chaff, while the sample in phase 5 produced only rare denser chaff.

Table 6.14 Occurrences of frequent desiccated 'light chaff' (awns, glume fragments etc) in relation to grain and dense chaff items.

	01S/004	02CF/047	1/2S/048	05RF/401	06F/402	06F/513
Total desiccated grain	5	5	7	14	0	0
Total desiccated quantified chaff	136	200	295	8	0	0
Desiccated culm nodes	7	2	4	0	0	0
Desiccated light chaff (glumes/awns etc)	+++	+++	+++	+++	+++	+++

The presence of light chaff in these samples which were generally poor in desiccated remains is suspicious and raises the possibility of contamination. Alternatively light chaff may have been used, for example as temper in bricks or plaster and consequently survived more fully than it would have otherwise. The large quantities of light chaff in samples from phases 1 and 2 occur in samples in which rachis is particularly numerous. It is likely therefore that the glumes and awns in these samples entered the site with the rachis; that is they represent the waste product from a range of early processing stages (threshing, winnowing and coarse sieving) rather than specifically from winnowing. Light chaff was much less frequent in the charred assemblages given its poor survival rate following burning. Where it was present in modest quantities it tended to be dominated by awn fragments which survive rather better than glumes.

6.4.7 Summary of cereal processing evidence

A summary of the processing stages indicated by the various ratios is presented in tables 6.15 and 6.16. It is immediately clear that for the charred samples the various ratios indicate the presence of processing by-products rather than processed grain. Only one sample can be argued to contain grain product alone, sample 09F/599, which produced grain of *Pennisetum glaucum*, with no weeds or chaff (very occasional fruit remains were present). The number of grains in the sample and the density of grain (crop product/volume ratio of 2.70) do not, however, indicate a deposit of grain of any size and certainly not any sort of *in situ* accidentally burnt stored product. Other examples where grain product is identified are based on the ratio of culm nodes/grain which is not reliable given the reduced chance of culm nodes surviving charring (this ratio is consequently only reliable if it indicated crop processing by-product). Indeed in these samples other ratios point to processing by-product, for example sample 03PF/105 in which culm nodes/grain suggests grain product, while rachis to grain indicates the presence of both *Hordeum vulgare* and *Triticum aestivum/durum* rachis.

There are a number of samples which appear to contain both processed product of one crop (usually *Pennisetum glaucum*) with the processing by-product of another (*Triticum aestivum/durum* or *Hordeum vulgare*). As an example of this sample 03PF/106 clearly contains a large deposit of grain of *Pennisetum glaucum* (341 grains) and relatively few weed seeds, but also contains large amounts of *Hordeum vulgare* and *Triticum aestivum/durum* rachis as well as a high weed/non-millet grain ratio.

Table 6.15: A summary of crop processing evidence suggested by chaff, grain and weed ratios of charred remains

Sample	Classification	Ratio 1	Ratio 2	Ratio 3
01S/022	by-product of early processing stage	Hordeum rachis/grain ratio (79)	Triticum rachis/grain ratio (132)	
	by-product from late processing stage	weeds/grain (4.33)	weeds/grain2 (32.5)	
	mixed	culm node/all grain (0.8)	small/large weeds (1.5)	
03F/102	by-product of early processing stage	Hordeum rachis/grain ratio (1.48)		
	mixed	weed/grain2 (1.1)	weeds/grain (1.1)	
03PF/105	by-product of early processing stage	Hordeum rachis/grain ratio (8.33)	Triticum rachis/grain ratio (38.57)	
	grain product	culm node/all grain (0.3)		
	by-product from late processing stage	weeds/grain (15.22)	weed/grain2 (41.1)	
	by-product from sieving	small/large weeds (2.34)		
03PF/106	by-product of early processing stage	Hordeum rachis/grain ratio (5.5)	Triticum rachis/grain ratios (196.0)	
	grain product	Pennisetum glaucum involucre/grain (-)	weeds/grain (0.35)	
	by-product from late processing stage	weeds/grain2 (11.18)		
	by-product from sieving	small/large weeds (6.24)		
	grain product/mixed	culm nodes/all grain (0.14)		
03RF/108	by-product of early processing stage	Hordeum rachis/grain ratio (15.0)		
	by-product from late processing stage	weeds/grain (13.25)	weeds/grain2 (13.25)	
	by-product from sieving	small/large weeds 25.5)		
04CF/129	grain product	culm nodes/all grain (0.08)		
	by-product from late processing stage	weeds/grain2 (4.27)		
	by-product from sieving	small/large weeds (3.0)		
	mixed	weeds/grain (1.64)		
04F/383	mixed	weeds/grain (1.0)	weeds/grain2 (1.07)	
04I/128	by-product of early processing stage	Hordeum rachis/grain ratio (19.70)	Triticum rachis/grain ratios (20.88)	culm nodes/all grain (3.26)
	by-product from late processing stage	weeds/grain (4.61)	weeds/grain2 (7.51)	
	by-product from sieving	small/large weeds (4.72)		
04RF/121	mixed	weeds/grain (0.93)	weeds/grain2 (0.93)	
04S/104	mixed	weeds/grain (1.5)		
05F/363	by-product from late processing stage	weeds/grain (2.30)	weeds/grain2 (2.56)	
05F/366	by-product of early processing stage	Hordeum rachis/grain ratio (0.85)		
	grain product	culm node/all grain (0)		

	by-product from sieving	small/large weeds (5.83)	
	mixed	weeds/grain2 (1.52)	weeds/grain (1.46)
05F/389	by-product of early processing stage	Hordeum rachis/grain ratio (315.0)	
	by-product from late processing stage	weeds/grain (40.0)	weeds/grain2 (40.0)
	by-product from sieving	small/large weeds (39.0)	
05PF/361	by-product of early processing stage	Hordeum rachis/grain ratio (0.84)	
	grain product	culm nodes/all grain (0)	
	mixed	weeds/grain (0.57)	weeds/grain2 (0.84)
05RF/401	by-product from late processing stage	weeds/grain (5.83)	weeds/grain2 (5.83)
	by-product from sieving	small/large weeds (7.75)	
05S/382	by-product of early processing stage	Hordeum rachis/grain ratio (1.51)	
	grain product	culm node/all grain (0.02)	
	by-product from sieving	small/large weeds (2.48)	
	mixed	weeds/grain (1.22)	weeds/grain2 (1.83)
05S/385	by-product of early processing stage	Hordeum rachis/grain ratio (1.86)	
	by-product from late processing stage	weeds/grain (2.88)	weeds/grain2 (3.50)
	by-product from sieving	small/large weeds (7.17)	
05S/387	by-product from late processing stage	weeds/grain (2.25)	weeds/grain2 (2.25)
05S/390	unprocessed ear	Hordeum rachis/grain ratio (0.36)	
	grain product	culm nodes/all grain (0.04)	
	by-product from sieving	small/large weeds (10.63)	
	mixed	weeds/grain (1.16)	weeds/grain2 (1.39)
05S/408	by-product from late processing stage	weeds/grain (2.0)	weeds/grain2 (2.0)
05S/410	grain product	culm nodes/all grain (0.38)	Pennisetum glaucum involucre/grain (-)
	by-product from late processing stage	weeds/grain2 (161.0)	weeds/grain (5.55)
	by-product from sieving	small/large weeds (19.13)	
05S/411	by-product of early processing stage	Hordeum rachis/grain ratios (8.43)	
	by-product from late processing stage	weeds/grain (9.7)	weeds/grain2 (13.86)
	by-product from sieving	small/large weeds (8.7)	
05S/415	by-product of early processing stage	Triticum rachis/grain ratio (22.5)	
06F/400	by-product of early processing stage	Hordeum rachis/grain ratio (22.0)	
	by-product from late processing stage	weeds/grain (4.79)	weeds/grain2 (5.58)

	by-product from sieving	small/large weeds (6.44)		
	mixed	culm node/all grain (0.79)		
06F/402	by-product of early processing stage	Hordeum rachis/grain ratio (1.15)		
06F/513	by-product of early processing stage	Hordeum rachis/grain ratio (1.75)		
	by-product from late processing stage	weeds/grain (2.05)	weeds/grain2 (2.14)	
	by-product from sieving	small/large weeds (2.0)		
	mixed	culm nodes/all grain (0.73)		
06F/534	by-product of early processing stage	Hordeum rachis/grain ratio (6.15)		
	grain product	culm nodes/all grain (0.11)		
	by-product from late processing stage	weeds/grain2 (2.06)		
	by-product from sieving	small/large weeds (4.0)		
	mixed	weeds/grain (1.25)		
6/7PF551	mixed	weeds/grain (1.0)		
07CF/549	by-product of early processing stage	Hordeum rachis/grain ratio (8.72)		
	by-product from late processing stage	weeds/grain (11.21)	weeds/grain2 (14.20)	
	mixed	culm nodes/all grain (0.13)	small/large weeds (1.35)	
07S/592	by-product of early processing stage	culm nodes/all grain (6.38)	Hordeum rachis/grain ratio (5.88)	
	by-product from late processing stage	weeds/grain (8.13)	weeds/grain2 (8.13)	
	by-product from sieving	small/large weeds (7.13)		
09F/599	grain product	culm node/all grain (0)	Pennisetum glaucum involucre/grain (-)	weeds/grain (0.04)

Table 6.16: Summary of crop processing evidence as suggested by desiccated grain, chaff and weeds

Sample	Classification	Ratio 1	Ratio 2	Ratio 3
01S/003	by product from early processing	Hordeum rachis/grain (3.0)	Triticum rachis/grain (83:0)	Pennisetum chaff/grain (21.75)
	by-product from sieving	small/large weeds (35.5)		
	by-product from fine sieving	weeds/grain (10.43)	weeds/grain2 (16.2)	
01S/004	by product from early processing	Triticum rachis/grain (87:0)	Pennisetum chaff/grain (8.0)	
	by-product from sieving	small/large weeds (6)		
	by-product from fine sieving	weeds/grain (11.2)	weeds/grain2 (56)	
01S/022	by product from early processing	Pennisetum chaff/grain (11.5)		
	by-product from sieving	small/large weeds (8.4)		
	by-product from fine sieving	weeds/grain (15.67)	weeds/grain2 (47)	
02CF/047	by product from early processing	Pennisetum chaff/grain (57.3)		
	by-product from sieving	small/large weeds (8.6)		
	by-product from fine sieving	weeds/grain (9.6)	weeds/grain2 (24)	
1/2S/048	by product from early processing	Triticum rachis/grain (26:0)	Pennisetum chaff/grain (43.9)	
	by-product from sieving	small/large weeds (2)		
	by-product from fine sieving	weeds/grain (-)	weeds/grain2 (-)	
03CF/046	by product from early processing	Hordeum rachis/grain (4.4)	Triticum rachis/grain (42:0)	Sorghum chaff/grain (63.0) Pennisetum chaff/grain (38.1)
	by-product from sieving	small/large weeds (24.5)		
	by-product from fine sieving	weeds/grain (10.2)	weeds/grain2 (30.6)	
04PF/107	by-product from sieving	small/large weeds (7.67)		
	by-product from fine sieving	weeds/grain (-)	weeds/grain2 (-)	
05F/366	by product from early processing	Hordeum rachis/grain 274:0)		
	by-product from sieving	small/large weeds (-)		
	by-product from fine sieving	weeds/grain (-)	weeds/grain2 (-)	
1/2S/048	by product from early processing	Hordeum rachis/grain (61:0)		

The majority of samples contain evidence for both early and late (fine sieving) stages of processing by-product: frequent rachis and some times culm nodes as well as frequent weed seeds to grain and small to large weed seeds (e.g. samples 01S/022, 03RF/108, 04CF/129, 04I/12805F/366). The presence of the early processing stages in these samples is undeniable, consisting of often large numbers of rachis segments. The evidence for late stage processing is based on weed seeds (small to large and weeds to grain). In the case of hulled cereals (e.g. *Triticum dicoccum*) fine sieving tends to take place at a late stage of processing, possibly on a day to day basis immediately prior to consumption and after de-hulling. In the case of a free-threshing cereal the fine sieving could take place alongside coarse sieving and winnowing prior to storage, so is not necessarily a late stage in the same sense. These samples could then contain both winnowing/coarse sieving waste and fine sieving waste produced at the same location, and as such the distinction of coarse and fine sieving is of limited value. These samples may also include weed seeds which entered the deposits via a different route, for example with animal dung or as fodder. The bulk of the cereal remains and arable weed seeds in the samples are therefore believed to derive from winnowing/coarse and fine sieving of *Hordeum vulgare* and *Triticum aestivum*, mixed with other refuse including *Pennisetum glaucum* product or tail grain, minor cereal crops, fruit remains, other minor crops and fodder plants.

The by-product from early stages of processing of *Hordeum vulgare* is particularly well represented in the samples, present in at least 14 charred samples. Conversely the by-product of early stage processing of *Triticum aestivum/durum* rachis (including *Triticum* X type) is represented in only five samples, although in each case convincingly so: samples 01S/022, 03PF/105, 03PF/106, 04I/128 and 05S/415. Sample 04I/128 also contained large quantities of culm nodes and root nodes, suggesting whole lengths of uprooted straw were present. This sample was unusual in that the *Triticum* rachis present was identified as *Triticum* X type, perhaps suggesting that this particular wheat type was favoured for its straw.

The desiccated cereal remains are entirely classed as the by-product from early or late processing stages. No examples of processed grain product were represented. While this may in part be a reflection of differential preservation of grain (grain tends to survive as desiccated remains poorly), the abundance of chaff is undeniable. The ratio of small to large weed seeds again suggests fine sieving waste, although as mentioned above this could take place with the earlier stages of crop processing. Much more significant in the desiccated samples is the dominance of *Pennisetum glaucum* chaff (quantified on the basis of involucres, but including whole rachis and panicles), and in one sample *Sorghum bicolor*. The representation of these particular crops, which are so poorly represented in terms of charred chaff, is undoubtedly largely due to preservation. The *Pennisetum glaucum* chaff in particular is fragile and while no experimental data are available to demonstrate differential survival it is unlikely that it would survive in significant quantities except in very unusual situations. This then raises the possibility that in the charred deposits the *Pennisetum glaucum* chaff has simply not survived.

6.5 Crop Processing Activities: Cotton

The non-cereal crops present at Jarma are dominated by fruits and some nuts which require little or no processing. Cotton (*Gossypium* sp.) conversely, which is best represented in the Garamantian phases 5 and 6, requires significant processing from harvest to weaving. Much of the cotton produced in North Africa today is machine-spun, although in some parts of the Nile Valley and in Ethiopia cotton is still prepared and spun by hand. Spring and Hudson (1995) compare accounts from mid-nineteenth century Ethiopia (Johnston 1844 vol. 2: 162, 321-2), Sudan (Crowfoot 1924: 83-9) and Nigeria (Picton and Mack 1989: 30-32). The accounts suggest that the process is broadly similar and in each example it involves three basic stages: ginning (to remove the cotton seeds from the boll), bowing or combing (to separate the fibres ready for spinning) and spinning, although the importance of the bowing or combing stage appears to vary, in parts of the Sudan apparently avoided altogether (Crowfoot 1924, 84).

Johnston (1844) describes the ginning of raw cotton in 19th century Ethiopia as follows:

> "Flat stones, something larger than bricks, with a smooth upper surface, were placed upon the ground, my three factory girls kneeling down before them, each with an iron rod in her hands, about twelve inches long, and three quarters on an inch in the middle, tapering to the extremities. This instrument is called a *medamager* [*madamacha*]; and with it a small quantity of seeded tufts of cotton, being laid upon the near end of the stone, is rolled out; the seeds, by the pressure being forced before the *medamager*, until they fall over the farther extremity of the stone. By this simple, but very effectual process a large portion of the cotton was soon in a state fit to be farther cleaned from dust and other extraneous matter and which is the next part of the process it has to be submitted to before it is in a fit condition to be spin into thread."
>
> (Johnston 1844, vol. 2.:321-2, quoted in Spring and Hudson 1995).

Johnston does not mention what happens to the seeds, although it is conceivable that as seeds fell off the end of a ginning brick they were swept or thrown onto fires. Presumably the scale of processing and consequently the waste would be related to social structure and the role of cotton within the economy. If cotton cultivation and processing was practiced on a domestic level we might expect a slow deposition rate of seeds. If production was on a more industrial scale (as an extreme example in the factories of 19th century northern England) then we might expect a high density of seeds indicative of rapid deposition.

Cotton seeds at Jarma are never present in high densities or large numbers (the maximum number of seeds in an individual sample is 20), although they are recovered in numerous samples in phases 5 and 6, particularly phase 5 where they occur in 50% of samples. This distribution would therefore suggest regular small scale deposition. Samples in which more than one or two seeds were recovered were hearth/fire sample 04I/128 (9 seeds), pit fill sample 05PF/361 (20 seeds), the large phase 5 spread (context 607), sample 05S/390 (13 seeds) and a floor deposit within the southern phase 6 house 06F/400. Seeds were recovered in numbers of up to 5 from room fills, floors and spreads and pit fills. It is difficult to draw any conclusions from the distribution within individual contexts, other than it is likely that they are frequently the result of waste product burnt on domestic fires and subsequently redistributed as waste with other spent fuel.

In contrast cotton seeds found in early Islamic period contexts (9th century) at Volubilis, Morocco (Fuller, Pelling and De Varailles *forth.*) were present in few contexts in large numbers. The cotton at the site is likely to have been imported from cotton growing regions further south. Towns such as Volubilis and near by Al-Basra are believed to have been involved in textile production on a significant scale in the early Islamic period (e.g. Ibn Hawkal 1842), as is still the practice in the area today. It is likely therefore, that cotton was imported as cotton bolls and processed on an industrial or semi-industrial scale, thus resulting in few samples with large numbers of seeds. At Jarma it is therefore suggested that cotton processing was conducted on a small domestic scale and the seeds found their way into domestic fires and refuse.

6.6 Correspondence Analysis

As a means of further exploring the internal composition of samples, correspondence analysis was employed to search for patterns in the data. As discussed in the methodology chapter (chapter 3) correspondence analysis (CA) is an ordination technique, used by both ecologists and archaeologists, which plots samples and taxa on 3 axes, according to their relative inertia to one another (Shennan 1997). The greatest inertia is usually expressed in axes one and two. Samples that plot closely together can be assumed to have similar characteristics, while samples which plot far apart are assumed to be significantly different. Ecological variables where known, crop processing activities, context type, time variables and so on can then be explored in an attempt to establish which factors can be argued to affect the distribution. Data were first standardised in Excel while the correspondence analysis was conducted using the programme PAST ver. 1.38 (Hammer, Harper and Ryan 2006). The formation processes involved in charred and desiccated deposits are different and therefore they cannot be treated equally in the statistical analysis. The number of samples with sufficient quantifiable desiccated material (i.e. 8 samples) is too small to allow meaningful analysis (e.g. Gauch 1984, 6). Therefore only charred samples are used in the correspondence analysis.

6.6.1 Data preparation

Prior to the application of correspondence analysis the data were manipulated in order to standardise it. Unidentifiable and/or unquantifiable seeds or other items (such as stem fragments or glume or awn fragments) were not included in the analysis. Positive and provisional scores for the same taxa were combined (e.g. *Portulaca oleracea* and cf. *Portulaca oleracea* were combined as a single score). While this does run the risk of combining different taxa, in most cases the items given only tentative identification were present in samples were a large number of that same item were well preserved, thus the tentatively identified item is very likely to be a poorly preserved example of the same taxon. Where only cf. identifications were made their tentative identification will make no difference to the exploration of sample composition so their inclusion was not a problem.

All taxa were given a code. Those taxa which were identified to variable levels, but are likely to have derived from the same taxon or taxon type (e.g. *Triticum durum*, *Triticum aestivum*, *Triticum* X type, *Triticum aestivum/durum*) were combined by giving the same code. The codes used are given in table 6.17. Seed fragments or detached items such as embryos, *Triticum* rachilla or free-threshing *Triticum* glume fragments were not included. Other non-seed items such as thorns, leaves and so on were included in the initial analysis. For cotton the count for 'total seed' only was used.

Finally certain samples and taxa were omitted from the matrix. Samples with only few identifiable seeds are not regarded as reliable and any resulting analysis involving those samples would be regarded as inaccurate. The larger the sample (i.e. the more items it contains) the greater the accuracy. Samples containing fewer than 50 identifications were excluded from the analysis. While a cut off point of 100 (or 400-500) would produce more reliable results (Van der Veen 1992b, 25; Van der Veen and Fieller 1982), this would have resulted in a considerable loss of 45 samples out of a total of 64 (i.e. 70% of samples). By using a cut off point of 50 identifications only 29 samples are lost (i.e. 45%). The inclusion of rare taxa can be problematic in multivariate statistics, particularly in archaeological material in that their presence may be a matter of chance, or for example, part of the background noise of a site, and may obscure patterns in the data (Gauch 1984). A cut of point of 5 to 10 % is most commonly applied to ecological or archaeological data (e.g. Gauch 1982; Lange 1990; Van der Veen 1992b), while the adequacy of a 10% cut off has been demonstrated for ethnographic material from the Island of Amorgos, Greece (G. Jones 1984). In the current study, using all identifications, the 10% cut off reduced the number of species/items from 141 to 72, a reduction of 52%, with a total number of identifications of 9759 (a reduction from 10759). The 5% cut off took the number of taxa from 141 to 96, a reduction of 33%, resulting in 9986 identifications. Given the fact that the reduction in total identifications was so little, it was decided that the 10% cut off point would be the most reliable and didn't actually loose a significant quantity of data. The resulting data matrix consisted of 34 samples and 72 taxa. Table 6.18 lists the samples used.

Table 6.17 Taxa and codes used in the first stage of correspondence analysis (taxa marked with a * were removed in the course of the analysis)

Code	Taxa	Code	Taxon
Triaes/dur-c	*Triticum aestivum/durum*, grain	Chenopod-c	Chenopodiaceae small
Tritsp.-c	*Triticum* sp., grain	Cornmon-c	*Cornulaca monacantha*
Horvul-c	*Hordeum vulgare*, grain	CrucicV-c*	Cruciferae V
Sorbic-c*	cf. *Sorghum bicolor*, grain	CyperA-c	Cyperaceae A
Pengla-c	*Pennisetum glaucum*, grain	Euphel-c*	*Euphorbia helioscopia*
Indetgrain-c	Cerealia indet., grain	Euppep-c	*Euphorbia peplus*
Triaes/durrac-c	Triticum aestivum/durum, rachis	Alhagitype-c	*Alhagi* type seed
Horvulrac-c	*Hordeum vulgare*, rachis	Legumlr-c	Fabaceae, large/intermediate
Indetrachis-c	Cerealia indet., rachis	Legumsm-c	Fabaceae , small
Cerealculm-c	Cereal size , culm node	Plasp.-c	*Plantago* sp.
Legumelg-c	Fabaceae, cultivated	Reslut-c	*Reseda lutea*
Ficcar-c	*Ficus carica*	Solsp.-c	*Solanum* sp.
Vitvin-c	*Vitis vinifera*	Solonac-c	Solonaceae
Vitvinstk-c	*Vitis vinifera*, stalk	Suasp.-c	*Suaeda* sp.
Phodacston-c	*Phoenix dactylifera*, stone	Cynodon-c*	*Cynodon* sp.
Phodacrper-c	*Phoenix dactylifera*, perianth	Polsp.-c	*Polypogon* sp.
Phodacrach-c	*Phoenix dactylifera*, rachilla	JarmaGramR-c	Poaceae R
Cucurbitaceae-c	cf Cucurbitaceae	Grasslg-c	Poaceae large indet.
Pungra-c	*Punica granatum*	Grasssm-c	Poaceae, small indet.
fruitindet-c	Fruit, indet. frags	Grassindet-c*	Poaceae, embryo
Apigra-c	cf. *Apium graveolens*	Horsp.-c	*Hordeum sp.*
Oleaeur-c	*Olea europea*	Panicaea-c	Paniceae indet.
Ole/Zuz-c	*Olea/Zizyphus* sp.	Phasp.-c	*Phalaris* sp.
Linussd-c	*Linum usitatissimum*	Setver-c*	*Setaria verticillata* type
Gossyp-c	*Gossypium* sp.	Pantur-c	*Panicum* cf. *turgidum*
Zizspin-c	*Zizyphus* sp.	JarmaPanA-c	*Panicum repens*
Aca/Prossp-c	cf *Prosopis* sp.	Brar/d-c	*Brachiaria ramosa/deflexa*
Aizhisp-c	*Aizoon* cf. *hispanicum*	Setver/Br-c	*Setaria verticillata/Brachiaria ramosa*
Amaaug-c	*Amaranthus* cf. *augustifolius*	Br/S/E-c	*Brachiaria/Setaria/Echinochloa* type
Anaarv-c	cf. *Anagallis arvensis*	Brosp.-c	*Bromus* type
Apiaclg-c	Apiaceae, large seeded	JarmaTypeT-c	TypeT
Apiacsm-c*	Apiaceae, small seeded	JarmaTypeF-c	Type F
ApiacA-c	Apiaceae A	JarmaP-c	Type P, leaf
Aspten-c	*Asphodelus* cf. *tenuifolius*	Tamarix-c	*Tamarix* sp., leaf frags
BorogA-c	Boraginaceae A	bud/flower-c	Other' bud/flower
Chen/Amar/-c*	Chenopodiaceae/Amaranthus sp.	Mimosthorn-c	Mimosaceae type thorn

6.6.2 The results of the Correspondence Analysis

Figures 6.8 and 6.9 show the ordination plots on the first two and the second two axes using the 10% cut off point. In figure 6.8 there is one clear outlier, 03PF/106, at the bottom left hand corner of the plot. On the second and third axes sample 03PF/106 is still an outlier, while samples 03PF/105, 04I/128, 05S/410, 05S/589, 06F/400 and 07CF/549 are less extremely removed. The outliers, while not extreme, do obscure the remaining data and as they are clearly of different character they can be removed to enable patterns in the remaining data to be examined.

Table 6.18 Samples used in the initial correspondence analysis giving the total items included.

Sample	Type	Total items	Sample	Type	Total items
01S/022	spread	317	05S/387	spread	86
03F/102	floor	88	05S/390	spread	416
03PF/105	pit fill	666	05S/408	spread	58
03PF/106	pit fill	756	05S/410	spread	217
03RF/108	room fill	126	05S/411	spread	219
04CF/129	courtyard fill	177	05S/415	spread	72
04F/383	floor	69	06F/400	floor	480
04I/128	fire	1631	06F/402	floor	65
04RF/121	room fill	69	06F/405	floor	60
05F/363	floor	144	06F/407	floor	60
05F/366	floor	148	06F/513	floor	395
05F/386	floor	55	06F/534	floor	773
05F/389	floor	383	06RF/520	room fill	97
05PF/361	pit fill	118	06RF/521	room fill	56
05RF/401	room fill	120	6/7PF551	pit fill	236
05S/382	spread	396	07CF/549	courtyard fill	799
05S/385	spread	175	07S/592	spread	232

Initially sample 03PF/106 was removed, which also removed two species (Grassindet-c and Setver-c). The resulting plot (fig. 6.10) placed sample 03PF/105 as a clear outlier on the 1st and 2nd axes. The removal of 03PF/105 in turn resulted in one outlier, 07CF/549 (fig. 6.11). Figures 6.12 and 6.13 show the plots once three outliers had been removed. The samples are distributed in a much clearer arch than in previous plots with one sample (05S/410) separated to the top of the plot. While the removal of this fourth sample opened up the cloud slightly (fig. 6.14) it still resulted in a fairly similar plot along the 1st axes. The position of some samples has shifted along the 2nd axis. There is clearly some spread with some samples plotted some way from the remaining data cloud, but the distribution is fairly even and the extent of pull of these samples fairly limited. This final data matrix consisted of 31 samples and 64 taxa with a total of 7267 identifications. Table 6.19 lists the outliers that were removed at each step with a brief description of the possible explanation for their distribution away from the data cloud.

Table 6.19 The outliers removed during CA and possible explanation for their distribution

Outlier	Explanation
03PF/105	Contained large quantities of chaff, especially *Triticum aestivum/durum* rachis
03PF/106	Contained large quantities of chaff, especially *Triticum aestivum/durum* rachis and a large number of *Pennisetum glaucum* grain.
05S/410	*Pennisetum glaucum* grain, *Solanum* sp. and Jarma *Panicum repens* dominate
07CF/549	Dominated by frequent chaff, date stone, Chenopodiaceae /Amaranthaceae and *Alhagi* type/Leguminous seeds

Table 6.20 The Eingenvalues generated at each stage of the CA as outliers were removed

Outliers Removed	Eigenvalue 1	Eigenvalue 2	Eigenvalue 3	Eigenvalue 4	Outliers remaining
None	0.47463	0.33246	0.293376	0.243163	03PF/106
03PF/106	0.45614	0.31812	0.267915	0.252462	03PF/105
03PF/105	0.38004	0.32416	0.282405	0.211174	07CF/549
07CF/549	0.40043	0.29023	0.214476	0.175275	05S/410
05S/410	0.39967	0.21945	0.19347	0.176992	

Figure 6.15 shows the final plot using symbols for phase without labels. There appears to be a slight time trend, with samples from the earlier phases showing a slight distribution to the right. However this time trend is only very slight and there are notable exceptions: a phase 4 hearth sample, 04I/128, a phase 5 floor sample, 05F/389 and phase 6 floor sample 06F/400, all of which plot to the left. The distribution can not be entirely explained by change through time therefore, and in fact it could be argued that the composition of the samples is remarkably stable through time. Three samples are plotted high on the second axis, slightly away from the main group: hearth sample 04I/128, plotted to the left, pit fill sample 6/7PF551 and floor sample 06F/534, both in the top right hand corner of the plot. When sample points were replaced by feature type codes no obvious pattern could be seen with the exception of the hearth sample 04I/128 which was situated to the left of the plot and slightly higher than the main group. There does not appear to be any clear distribution by sample type with the exception of the hearth sample.

Figure 6.16 shows the same plot with taxa codes superimposed. It is immediately obvious that a limited number of taxa are affecting the distribution. Date stones (Phodactston-c) plot to the far right away from the main data cloud and are presumably creating the slight chronological pull in that direction. Seeds of fig plot high on the second axis in the centre of the 1st axis, suggesting that they are pulling samples 04I/128, 6/7PF551 and 06F/534 upwards. Cereal chaff (indeterminate rachis, barley rachis, free-threshing wheat rachis and culm nodes) and seeds of Apiaceae A type are plotted to the left indicating that it is the chaff which is pulling samples in this direction.

To test the notion that chaff and fruit are affecting the spread, the sample codes were replaced by symbols based on the composition of the samples as indicated in section 6.2, that is chaff rich, fruit rich, grain rich or mixed. A sample is treated as 'rich' in one category if it forms more than 70% of that sample. Samples which are essentially mixed but do have more than 50% of one item are classified separately, so for example mixed samples with a high percentage of fruit are indicated. The resulting plot is shown in figure 6.17 which does appear to demonstrate that the proportion of chaff or fruit are affecting the plots, chaff rich samples pulling to the left and fruit rich upwards and to the right.

The majority of samples cluster around the centre of the data cloud (+0.01, 0). The samples involved are from a range of context types, and derive from phases 7 to 4. These samples are clearly predominantly 'mixed' in terms of the ratio of chaff to grain to weed seeds to fruit, and the fact that they plot closely together would confirm that the internal composition is broadly similar. Samples taken from phases 5 and 6 are particularly numerous in this central cluster. Many of the phase 5 samples were taken from a large deposit of burnt organic material (context 607). Samples from phase 6 included a range of domestic contexts. The similarity of these samples is likely to reflect a fairly uniform origin derived from a limited range of repetitive activities or mixtures of waste. The feature types represented are spreads, floors, room fills, a courtyard fill and one pit fill. The similarity of the sample composition can be explained if the majority of deposits represented are derived from midden type material made up of a mixture of animal fodder, animal pen waste, domestic waste, routine crop processing activities and so on which has been back filled into abandoned houses or rooms and pits. The fact that the samples within the central part of the plot are from a range of time periods (from phase 7 through to phase 3) suggests that waste formation within the site actually changed little over time.

The two samples which are situated in the top right corner of the plot are samples 06F/534 and 6/7PF551, the first one a floor, the second a pit fill. Both samples are rich in fig pips. Hearth sample 04I/128 in the upper left quadrant is also rich in fig pips but is distinguished from the other two fig rich samples by the high percentage of chaff remains and seeds of 'Apiaceae A'. All three samples also contain frequent date stone and grape pips. Samples 06F/534 and 6/7PF551, contain only rare cereal or weed remains. Sample 04I/128 also contains large numbers of culm nodes, *Triticum* X type and *Hordeum vulgare* rachis, and *Pennisetum glaucum* caryopses. *Triticum* X type has not been distinguished from other free-threshing wheat rachis in the correspondence analysis but the association between culm nodes and this taxon has been noted above with the suggestion that the straw may have been of particular value.

Fruit remains may have entered the charred deposits in a number of ways. The actual number of fig seeds in these samples is not great (161 to 370) when it is considered that one fruit might contain between 1000 and 2000 seeds, although they do form significantly greater proportions of the deposits than in other samples. Discarded, possibly rotten fruit may have been thrown onto domestic fires as waste. Grape or date stones may have been spat out onto fires casually, although it is unlikely fig seeds would have been treated in the same way. Date stones could have been removed during processing of the fruit for the removal of the flesh and thrown onto fires as waste. It is difficult to imagine a process which would have required the deliberate removal of fig or grape seeds, particularly fig which are more likely to be eaten. Fig and grape seeds are perhaps most likely to enter archaeological deposits via faecal matter (animal or human). Both species produce small robust seeds which tend to survive passage through the gut particularly well, and are commonly encountered in dung deposits or cess pits. Date stones may have derived from animal dung. There is no obvious evidence for dung in these samples in terms of dung type masses of organic matter, however this could be a product of preservation. In the case of sample 04I/128 then, it would appear that the chaff, particularly straw, and possibly dung has been used as fuel in a domestic hearth. The other two samples might include re-deposited burnt faecal material.

The samples which are situated in the bottom left hand corner of the plot, particularly samples 01S/022and 06F/400, and to a lesser extent 05F/389, are rich in chaff. Sample

05F/389 contains a large amount of *Hordeum vulgare* and indeterminate rachis, with a little fruit, grain or weed seeds. This sample also contains some sheep/goat droppings. Sample 01S/022 contains frequent *Triticum aestivum/durum* and *Hordeum vulgare* rachis and indeterminate culm nodes, with some date, some pearl millet and a range of weed seeds in low numbers. Finally sample 06F/400 produced mostly *Hordeum vulgare* rachis, but also frequent figs, other fruits and crops such as pomegranate and cotton, and a range of weed seeds. Those samples further to the bottom left hand corner of the plot have more chaff and fewer fruits, other crops or weed seeds, while fruit rich samples are towards the upper right. Samples in the middle tend to be mixed with fruits, chaff and weed seeds, cereal grain and other crops.

Given the mixed nature of the deposits it was decided not to take the correspondence analysis further. It is not possible to isolate weeds of cereal crops from wild fodder plants for example thus making interpretation of the data difficult. It is sufficient to argue that the majority of samples represent mixed deposits, while those with particularly high chaff or fruit content tend to separate from the main data cloud. The absence of any time trend would suggest that basic domestic activities and waste disposal remained fairly constant through time. The following section attempts to highlight some of the possible routes by which such material may have entered the deposits.

6.7 Pathways to deposition: fuel, fodder and temper

Archaeobotanical material from Jarma is preserved both by charring and in the later deposits by desiccation. The broad composition of the samples has demonstrated the significance of fruits in the charred samples, while the evidence for the importance of chaff and straw from threshing, winnowing and sieving is very strong. Cereal grain and the minor crops (pulses, nuts, flax, cotton and so on) are less dominant but are present as background 'noise' in many charred samples. Weed seeds and some wild plants are also represented, arable weeds presumably associated with the chaff as cereal processing waste. Desiccated samples are dominated by chaff with much less significant quantities of fruits or seed crops. The density of charred remains are such that there is no evidence for catastrophic burning events of stored products, but rather a gradual piecemeal deposition of material presumably charred in domestic (or possibly semi-industrial) hearths and fires.

The range of material represented would suggest that kitchen/domestic refuse, such as fruits and pulses, was burnt, as well as other material deliberately collected for fuel.

While occasional seeds of sesame or condiments may have entered domestic fires during processing or cooking activity the presence of other items is more complex. It has already been suggested that cotton seeds may have been thrown or swept into fires following domestic scale processing. Nut shells, pomegranate seeds, olive and date stones, and possibly grape seeds, could have been thrown or spat into fires. Large numbers of desiccated fruit seeds have been recovered from other sites in North Africa, where it has been suggested they derive from faecal material, for example at Mons Claudianus in the Egyptian Eastern Desert (Van der Veen 2001) or the Red Sea port of Berenike (Cappers 2006). A similar route of entry is possible for charred fig seeds, which also turn up at North African sites in large numbers (e.g., Eusperides, Pelling and Al-Hassey 1998; Carthage, Van Zeist *et al.* 2001; The Libyan Valleys sites, Van der Veen, Grant and Barker 1996). Date stones in particular were present in large numbers at Jarma. Date flesh is today commonly removed from the stone, pulped and rolled into balls or moulded into blocks for storage and for consumption as a sweet or snack. As such it represents a particularly valuable source of storable and tradable sugar. The stones are often ground into food for cattle, discarded, onto middens or floors, or burnt on fires.

The presence of large quantities of fruits and vegetables, particularly compared to Northern European sites where cereal grain and its by-products tend to dominate (Knörzer 1971; M. Jones 1985), must be in part a product of domestic refuse disposal methods. Patterns of refuse disposal may also be related to patterns of fuel use and the paucity of good fire wood. It is of interest to note the significance of fruits in phase 6 in particular, the contexts of which are mostly domestic. The large deposits of charred and other waste in house or courtyard fills suggest that refuse, including fire waste, was thrown onto middens within abandoned houses or courtyards, rather than removed to external middens. This pattern of refuse disposal must have contributed significantly to the make up of the site. Occasionally large pits were dug (for example in phase 6/7), possibly for refuse, although they did not tend to produce charred remains in any quantity. It is possible that if pits were used for refuse disposal (rather than for some ritual use associated with the temple) this negated the need for burning.

The importance of chaff and straw as an economic resource in arid environments, with particular reference to North Africa, has been stressed by Van der Veen (1999a). The major cereal crops represented at Jarma are free-threshing. All processing stages, with the exception of final cleaning by hand of grain immediately prior to use, are likely to have taken place outside of the settlement. Processing waste may then have been stored in the field or near the threshing floor, as is common practice in much of arid North Africa today (fig. 6.18), or moved elsewhere, possibly within the settlement. The abundance of chaff and associated weed seeds within the deposits, both desiccated and charred, therefore indicates it was brought into the site and as such serves an economic purpose in its own right. Van der Veen (1999a) identifies three likely uses of chaff: fuel, fodder and temper. The taphonomic processes involved in sample formation are discussed in relation to these three categories. Particular reference is made to chaff and straw while consideration is also given to other sources of fuel and fodder as suggested by the data.

6.7.1 Fuel

Much or all of the charred material recovered is likely to have been burnt as fuel, either casually or more deliberately. The identification of specific fuel types is however only possible by association with hearth, oven or kiln type features. While there were very few structural hearths at the site, there were several shallow pits or scoops with ashy fills which were sampled separately and are likely to be the result of fires: samples 03PF/303 (a fire pit), 04I/128 (a 'fire patch'), 04I/511 (a fire patch), 05PF/361 (shallow pit) and 06PF/517 (a pit/hearth). Pit sample 03PF/105 is believed to be associated with a *tanur* type bread oven situated next to it, and archaeologically is interpreted as containing rake out from the *tanur*. Of these samples two can be argued to provide evidence for the use of chaff and straw as fuel: 03PF/105 and 04I/128, while sample 05PF/361 was more mixed. The other three samples produced only small assemblages. Sample 03PF/105 produced a large amount of rachis, predominantly *Triticum aestivum/durum* (*T. aestivum* was most numerous, while four rachis internodes of *T. durum* were also identified), and with a much smaller amount of *Hordeum vulgare* rachis, date stones and frequent weeds including a large number of Fabaceae seeds and pods, seeds of *Portulaca oleracea* and small grasses including *Cynodon* sp.. Also present were fragments of palm fronds and numerous sheep/goat droppings. Sample 04I/128 produced frequent weed seeds including grasses, *Solanum nigrum*, frequent seeds of Apiaceae A., date, fig and grapes, culm nodes and rachis. *Hordeum vulgare* rachis was most frequent while *Triticum* X type was also numerous. These two samples therefore seem to indicate that a mixture of domestic refuse including fruit remains, and animal dung, or animal pen waste, were used as fuel in addition to cereal chaff. Both *Triticum* and *Hordeum* rachis appear to have been used as fuel.

It is likely that the majority of charred material recovered from the site represents spent fuel mixed with domestic refuse or midden material. The use of animal dung as fuel has been much commented on for sites in the Near East as well as chaff and straw or other non-wood fuel where woody vegetation is scarce (Miller 1984; Miller and Smart 1984; Miller 1991; Charles, 1998). The use of dung ash specifically for heating *tabūn* or *tanur* bread ovens has been noted in Jordan, Egypt and elsewhere (Palmer 2002, 179; Samuel 1989; Lyons and D'Andrea 2003). A similar pattern is possible in the Fazzān. Importantly, the data generally suggests that there is no deliberate selection for single fuel sources, but rather suggests the use of mixed waste, including dung and chaff, as well as domestic refuse.

6.7.2 Fodder

The inclusion of fodder in the samples would imply either the stabling or penning of animals within the site or the use of dung as fuel. The use of dung as fuel has already been suggested above. The identification of fodder and/or dung is most easily achieved through the recognition of the actual dung fragments, but can also be suggested on the basis of the biology and ecology of non-crop species as well as the behaviour of non-crop seeds in relation to crop processing, particularly where more than one stage of processing is indicated (Charles 1998). Three likely sources of fodder may be represented: chaff and straw, cultivated fodder crops and wild plants. Wild plants used as fodder will include species collected and brought to the animals, but also growing plants on which the animals are allowed to feed.

The use of chaff and straw as fodder and/or animal bedding is common place in North Africa, as it is in Europe and is likely to be a significant factor in the introduction of chaff and straw into archaeological deposits (Van der Veen 1999a). In arid areas there may be greater reliance on chaff where pasture and other sources of fodder are limited.

Archaeologically it is difficult to identify the use of chaff and straw as fodder conclusively without examination of dung fragments. The association of chaff rich samples with dung deposits might suggest its use as fodder and or/bedding but could also imply mixed deposits from a range of sources. Large deposits of sheep/goat droppings within archaeological deposits at Jarma indicate that penning of animals did take place within the site. In addition, the presence of charred dung in some samples suggests the use of dung as fuel. Several samples produced sheep/goat dung, some times in large quantities, both charred and desiccated. However, not all of the dung rich samples produced chaff or straw in any quantity. Sample 04PF/107 produced masses of desiccated sheep/goat droppings with frequent weed seeds but very little chaff. Sample 04CF/129 produced a large quantity of both desiccated and charred sheep/goat droppings with frequent fruit (particularly date, grape and fig) but very little chaff. Finally sample 03F/367 produced frequent charred sheep/goat droppings, with very little chaff or weeds and only few cereal grains or fruit. Further samples processed but not analysed produced large quantities of droppings with very few loose seeds or other remains at all. While chaff may have been used as fodder the nature of the dung of sheep/goat may be such that it does not survive being eaten and therefore does not enter the archaeological deposits via the dung. Samples 03F/102, 03PF/105 and 07S/592 conversely produced frequent droppings **and** winnowing/coarse sieving by product of *Hordeum vulgare* and in sample 03PF/105 winnowing/coarse sieved by-product of *Triticum aestivum/durum*. As discussed above, sample 03PF/105 is believed to be of the rake out of the adjacent *tanur*. Rather than the dung being the primary fuel source in this case it is suggested that dung was mixed with chaff for use as fuel.

The possibility of the use of chaff and straw for fodder still remains, particularly in the upper deposits where material is desiccated: much of the chaff here may represent stored fodder for example. The paucity of fruits and grain in the desiccated samples and the abundance of leaves would suggest kitchen waste is not so abundant and perhaps domestic activities were more limited than previous phases, especially if the leaves were deliberately collected for animal feed. Thus the deposits in these upper phases may derive in large part from the storage of fodder and presumably penning of animals within the site. The association of *Hordeum vulgare* chaff and animal droppings in samples 03F/102 and 07S/592 would suggest the deliberate selection of *Hordeum* chaff for fodder (the apparent use of mixed fuel types in sample 03PF/105 makes it difficult to establish which chaff type is associated with the dung). In the upper deposits the desiccated chaff of *Pennisetum glaucum* is dominant, which is found in association with sheep/goat droppings in several samples suggesting at least some of the chaff has entered the site as fodder or bedding. If the majority of chaff was brought into the site as fodder, this might explain the paucity of *Triticum* grain in relation to chaff. *Hordeum vulgare* grain as well as chaff was well represented in the samples, but while *Triticum* chaff was well represented the grain was not. If wheat was valued for human food it might be expected that fewer grains would be fed to the animals. If *Hordeum vulgare* was cultivated primarily as a fodder crop then it would be expected that more grain would enter the deposits as unprocessed waste.

The identification of certain wild herbaceous plants as fodder can also be suggested on the basis of association with dung. Where these species consistently occur with other species this then might imply by association they too represent fodder. Seeds of *Portulaca oleracea* and pod and seeds of *Alhagi* sp. were particularly numerous in samples 03PF/105 and 04PF/107, including seeds of both embedded in the sheep/goat droppings. Seeds of *Cynodon* sp. were also found incorporated in possible dung matrix although not in recognizable pellets or droppings and loose seeds were particularly numerous in sample 03PF/105, already identified as containing fodder and dung. *Portulaca oleracea* also occurred in large numbers in samples 03CF/046 and 01S/003 as desiccated seeds. Both samples also produced large amounts of chaff, particularly of *Pennisetum glaucum* and *Sorghum bicolor*. Other wild species which may represent fodder include *Cornulaca monacantha*, Cruciferae V, *Prosopis* sp. and various unidentified legumes, as well as the various small grasses. *Cornulaca monacantha* is a thorny shrub which is eaten by camels. The seeds and utricles are unlikely to have entered the site with cereal processing waste, but may have entered the site within camel dung, or may have been deliberately collected as fodder. Sample 07CF/549, identified as an outlier in the correspondence analysis, produced an unusual assemblage consisting of a limited range of wild species in large numbers including frequent utricles of *Cornulaca monacantha,* numerous leguminous seeds which may include *Alhagi* sp., already identified as a fodder plant, seed pods of Cruciferae V and grass seeds as well as large amounts of barley chaff, indeterminate rachis and culm nodes. The sample was clearly not composed of the usual mix of domestic refuse seen in the majority of samples, and did not contain the large amounts of *Portulaca oleracea* which has been particularly associated with sheep/goat dropping. This sample may instead have derived from camel dung or collected fodder for camels or cattle rather than sheep or goat. Seeds of *Prosopis* sp. were also present in this sample. *Prosopis farcta* has been identified as entering deposits via animal dung at the Bronze Age site of Abu Salabika in southern Iraq (Charles 1989) on the basis that while the plant grows in close association with cereal crops, its seeds do not develop until after the spring harvest. The seeds of this species are also used as a famine food and for tanning (Townsend and Guest 1974, 41). Its association with other potential fodder plants does suggest it has entered the Jarma deposits as fodder/dung.

6.7.3 Temper

Temper in mud brick and plaster has been identified as a potentially significant source of chaff and straw in archaeobotanical assemblages (Van der Veen 1999a). Fruit stones and seeds are also frequently used in temper, particularly date (authors own observations in Libya and Sudan). While the floatation of mud-brick samples was conducted macrofossils were not recovered. It is not clear if this is the product of a local building tradition or if for some reason the plant component of the temper did not survive. As desiccated remains tended to be concentrated in the upper levels of the site it is possible that in earlier deposits the temper simply did not survive while in the brick as it did not undergo charring. However, desiccated winnowing waste (light chaff) was recovered from phase 5 and 6 samples, in which no other desiccated chaff was recovered. It has already been suggested that use of temper may have facilitated its survival. Possibly here the chaff survived due to its use as temper. This is purely speculative however and it has not been possible to determine how significant eroding bricks and plaster were in terms of contributing to the chaff component on the site.

6.8 Summary

In this chapter the internal composition of samples has been explored using a variety of simple numerical methods including the use of ratios, percentage presence and ubiquity and by the use of correspondence analysis. The correspondence analysis has demonstrated that a broad similarity exists between many of the charred samples, the relative proportions of chaff and/or fruits resulting in the limited spread witnessed. In all phases the importance of chaff as an economic resource is suggested, in particular for fuel and fodder. The persistent representation of fruits is suggested to be the result of the use of domestic midden/refuse deposits for fuel. The use of animal dung as fuel and the presence of animal penning within the site is highlighted.

It is suggested that the activities which have led to the deposition of botanical material have remained constant throughout much of the occupation at the site. The exceptions to this are the early phases for which there is limited evidence and the later phases where desiccated deposits and particularly chaff dominate and fruits are limited. The later phases may be characterised by increased evidence for animal penning as the population of the site contracted although it is difficult to demonstrate this without the excavation of an increased area of the site. The majority of deposits on the site appear to have formed as the result of day to day domestic activities including food preparation, fuel use and animal penning, which have remained constant throughout and well beyond the period of increased Garamantian wealth. This would suggest that while Garamantian wealth is expressed in material goods or conspicuous consumption of imported artefacts (and some foodstuffs), domestic activities may not have changed. One exception to this is the domestic processing of cotton, suggested for Garamantian and late Garamantian periods, for which there is little post-Garamantian evidence. It is possible that cotton processing reflects an economic trend or market which was relatively short lived. The much more limited data for the temple and pre-temple phases may be related to a lack of domestic activity within the excavated area at that time.

A number of samples were identified as outliers in the correspondence analysis or as being of interest in terms of their internal composition. The four samples highlighted as outliers in the correspondence analysis are samples 03PF/105, 03PF/106, 05S/410 and 07CF/549. Each is discussed in turn.

Sample 03PF/105, is a pit sample possibly derived from the rake out of a *tanur*, and contained large quantities of chaff, especially *Triticum aestivum/durum* rachis, presumably used as fuel. This sample also contained sheep/goat dung, date stones, segments of palm frond and weed seeds including leguminous seeds and pods, *Portulaca oleracea* and grasses including *Cynodon* sp. This deposit is interpreted as mixed domestic refuse and animal dung used as fuel. The *Portulaca oleracea* and leguminous seeds and pods and some grasses are though to have derived from animal fodder.

Sample 03PF/106, a pit fill, produced large quantities of chaff, particularly *Triticum aestivum/durum* rachis and a large number of *Pennisetum glaucum* grain. This sample is interpreted as containing early stages of processing waste of free-threshing wheats mixed with processed pearl millet grain and other impurities. However, it is possible given the poor survival of *P. glaucum* chaff that the grain here is derived from processing waste, the small tail grain discarded with the processed panicles or removed by fine sieving. This is a possible explanation for the small size of the *P. glaucum* grain generally in archaeological deposits, if they are present largely as fine sieving waste rather then processed product.

Spread sample 05S/410 was dominated by grain of *Pennisetum glaucum* and seeds of *Solanum nigrum* and *Panicum repens*. Seeds of *Solanum nigrum* were numerous in two other samples, one from the same spread (05S/411) where it may represent the same deposit, and from hearth sample 04I/128. It is possible that these deposits represent limited culinary use of this plant.

Sample 07CF/549 produced an assemblage consisting of a limited range of wild species in large numbers as well as numerous date stones and chaff, mostly of *Hordeum vulgare*, and including culm nodes, suggesting barley straw is represented. The wild species include frequent utricles of *Cornulaca monacantha,* seeds of Chenopodiaceae/Amaranthaceae (presumably loose and poorly preserved seeds of *Cornulaca monacantha*), Fabaceae seeds, seed pods of Cruciferae V and grass seeds. While this sample does not contain any dung or dung fragments, the dominance of barley chaff and seeds/utricles of wild species including thorny shrubs are interpreted as derived from animal fodder or the dung of large herbivores, particularly camel.

Four additional samples were highlighted in the correspondence analysis as being rich in chaff. Sample 04I/128, taken from a hearth, produced frequent weed seeds including grasses, *Solanum nigrum*, frequent seeds of Apiaceae A., date, fig and grapes, culm nodes and rachis. *Hordeum vulgare* rachis was most frequent while *Triticum* X type was also numerous. In common with sample 03PF/105, this deposit seems to indicate that a mixture of domestic refuse including both chaff and possible dung/sewage as well as general domestic waste, was used for fuel. It is also suggested by the large number of culm and root nodes that *Triticum* X type was harvested by uprooting and possibly grown in part for its straw.

The samples which are situated in the bottom left hand corner of the final plot, particularly samples 01S/022 and 06F/400, and to a lesser extent 05F/389, were also rich in chaff, particularly of *Hordeum vulgare* and of *Triticum aestivum/durum* in sample 01S/022. Sample 05F/389 contains a large amount of *Hordeum vulgare* and indeterminate rachis, as well as some sheep/goat droppings, suggesting the use of barley rachis for fodder or bedding.

Finally a number of samples produced evidence for fodder by association with animal droppings (all sheep/goat) which further suggests the presence of fodder/dung in other samples by association of particular species. Samples 03F/102, 03PF/105 and 07S/592 are interpreted as including *Hordeum vulgare* chaff used for fodder. Sample 03CF/046 produced desiccated dung and frequent chaff of *Pennisetum glaucum* and *Sorghum*, as well as frequent leaves including of Type P and *Tamarix* sp., suggesting a mixture of millet/sorghum chaff and leafy material might have been used for fodder at least in the later phases of occupation at the site. Sample 04PF/107 conversely produced a large amount of sheep/goat droppings with only very limited chaff but with frequent seeds of *Portulaca oleracea* and *Alhagi* sp. seeds and pods, including seeds incorporated in the dung. A similar deposit of *Portulaca oleracea* and *Alhagi* sp. was recovered from sample 03PF/105, although charred and mixed with greater quantities of chaff. It is suggested that the *Portulaca oleracea* and *Alhagi* sp., as well as the animal dung, derive from sheep/goat pens which in the case of sample 03PF/105 had been used as fuel.

Chapter 7
THE AGRICULTURE OF THE FAZZĀN IN A PAN-REGIONAL CONTEXT

7.1 Introduction

The previous chapters have presented the archaeobotanical data from Jarma and Tinda B. The data from the earlier site of Zinkekra suggests that agriculture was introduced as a fully formed package which did not involve African domesticates (Van der Veen 1992a). This would suggest that agriculture arrived via the Mediterranean or the Nile Valley and was established in the Fazzān by the beginning of the 1st millennium BC. The introduction of two important African domesticates, pearl millet and sorghum, had occurred by the late 1st millennium BC with cotton introduced in the 1st millennium AD. This chapter explores the introduction of the key crops recorded in the Fazzān by examining data from across northern Africa. The following chapter will look at material culture in terms of what it might add to our knowledge of the various plant foods and the nature of their introduction.

7.2 A Database of African Archaeobotany

Archaeobotanical research in Africa is still a relatively new topic, yet even so the body of literature available and the number of archaeobotanical records is rapidly increasing. While several overviews exist which refer to or include the data from a range of sites, particularly in respect to the origins of agriculture (e.g. Neumann, 2003; Wetterstrom 1998), it was felt that a database of empirical data would be an invaluable research tool with which to explore pan-regional patterns more fully. A particular aim of the current study was to attempt to use the archaeobotanical remains themselves to explore the relationship between agriculture in the Fazzān and that of the surrounding regions, for example the relationship between the Fazzān and the Mediterranean regions compared to the Nile Valley or Egyptian Oases and Sub-Saharan regions. A database was therefore assembled containing records of the plant taxa represented on sites across Northern Africa, including a table of C14 dates where available. At present the database is limited to North Africa and the Sahel zone immediately to the south to the Sahara, although expansion of the database to cover the whole continent is possible for the future. While the Nile Valley data is important it was beyond the scope and resources of the current study to include all sites, and a separate database has been compiled for the region by Mary Anne Murray (UCL). Therefore a selection of sites form the major periods has been included (references supplied by Mary Anne Murray). The database includes several unpublished sites from Morocco, Algeria and Libya examined in the course of the current study (see appendices seven to ten for archaeobotanical data tables) as well as unpublished data given to the author by other archaeobotanists working in the area, or sites which are soon to be published (particular thanks are owed to Claire Newton, Alan Clapham, Dorian Fuller, Anna Maria Mercuri and Shawn Murray).

To date the archaeobotanical records for 61 sites have been entered, comprising 103 separated phases. Phases cover a period from 10,000 bp to the post-medieval period. The region covered so far includes Morocco, Algeria, Tunisia, Libya, Egypt and Sudan, Northern Nigeria, Mali, Burkina Faso, Mauritania and Ghana. Not all sites were included in the correspondence analysis (sites with seed impressions only or single grab samples were excluded) and those not included do not have a site code. The sites included in the data base are listed in tables 7.1 to 7.6. The site code prefix is given for each site used in the correspondence analysis. Phases were distinguished with phase codes (e.g. –Rom or –Byz).

Table 7.1 The Fazzān (northern Saharan) sites included in the database. Sites with no publication are those examined in this study.

Site Name	Site code	Period	Publication
Uan Tabu	UanT-	Epipalaeolithic - Mesolithic	Mercuri (2001)
Ti-N-Torha/Two Caves	Tora-	Epipalaeolithic - Neolithic	Wasylikowa (1992)
Uan Afuda	Afud-	Late Acacus	Castelletti *et al.* (1999)
Uan Muhuggiag	Uan-	Neolithic- Pastoral Neolithic	Wasylikowa (1992)
Zinkekra	Zinc-	Early Garamantian	Van der Veen (1992)
Tinda B	Tind-	Early Garamantian	
Jarma	Jarma-	Early Garamantian - 1931	
Aghram Nadharif	Agh-	Classic Garamantian	Mercuri *pers. comm.*

Table 7.2 The Maghreb sites included in the database with phase codes used in the correspondence analysis. 'Date Range' or 'Periods' are those given by the authors.

Site Name	Country	Site code	Periods	Publication
Al-Basra	Morocco	Basr-	Late Roman - Islamic	Pollock (1983-1984); Mahoney (1994); Pelling, appendix five
Badis	Morocco	Badis-	Islamic	Pollock (1983-1984)
Nakur	Morocco	Nakur-	Islamic	Pollock (1983-1984)
Qasr es-Seghir	Morocco	Seghir-	Islamic	Pollock (1983-1984)
Sijilmasa	Morocco	Siji-	Islamic	Mahoney, *unpubl.*
Volubilis	Morocco	Vol-	Late Roman - Islamic	Fuller, Pelling and De Varailles *forth*; appendix seven
Lambeisis	Algeria	Lam-	Roman	Pelling, appendix eight
Setif	Algeria	Setif-	Late Roman - Islamic	Palmer, C. (1991)
Carthage	Tunisia	Carth-	Punic - Medieval	Hoffman (1981); Van Zeist (1994); Ford & Miller (1978); Van Zeist *et al* (2001); Stewart (1984)
Leptiminus	Tunisia	Lept-	Roman – Late Antique	Smith, W (2001); Jezik (2000)
Eusperides	Libya	Eues-	Greco-Libyan	Pelling and al-Hassey (1998)
ULVS	Libya	ULVS-	Roman - Byzantine	Van der Veen et al (1996)
Lepcis Magna	Libya	LM-	Roman	Pelling appendix six

Table 7.3 The South West Saharan sites included in the Database. Date ranges given where available (uncalibrated dates given as bp).

Site Name	Country	Phase code	Period	Date Range	Publication
Dhar Nema	Mauritania	Nema-	Late - Early Tichitt	1970 – 200BC	MacDonald *et al.* (2003)
Oued Chebbi	Mauritania	Cheb-	Neolithic	3800-2400bp	Amblard Pernès (1989)
Dhar Tichitt	Mauritania	Tich-	Late Stone Age	1500 – 400BC	Munson (1971; 1976; 1986)
Karkarichinkat	Mali	Kark-	Late Stone Age	4000-3300BP	Smith (1992)
Winde Koroji	Mali	WinKir-	Late Stone Age	2100-1100BC	MacDonald (1996)
Dia Mara and Dia Shoma	Mali	Dia-	Iron Age – Post Medieval	800BC - 1900AD	Murray (2004)
Jenné-Jeno	Mali	Jene-	Late Iron Age – Late Islamic	400BC - 1510AD	McIntosh (1995)
Gao	Mali	Gao-	Islamic	6/7th - 16th C AD	Fuller (2000)

Table 7.4 The Egyptian sites included in the database. Date ranges given where available for the site.

Site Name	Site Code	Period	Date Range	Publication
Nabta Playa	NabP-	Early Neolithic	?11000-8200BP, 8100-7900BP, 7600-7330BP	Wasylikowa, *et al.* (1993; 1995; 1997); Wasylikowa, (1997); Wasylikowa & Dahlberg (1999)
Abu Ballas, Eastpans	Abu-	Neolithic	6200-6000BP	Barakat & Fahmy (1991)
Farafra, Hidden Valley	Fara-	Neolithic	7030+/-70 BP	Barakat & Fahmy (1991)
El Omari	Omar-	Neolithic/ Pre-dynastic	4600-4400BC	Barakat (1990)
Tell Ibrahim Awad	Awad-	Late pre-dynastic – Early dynastic		Thanheiser (1992)
Minshat Abu Omar	Mins-	Early Dynastic		Thanheiser (1992)
Kom el-Hisn	Kom-	Old Kingdom	2700BC-100/200AD	Moens & Wetterstrom (1988)
Lahun	Lahu-	Middle Kingdom		Germer (1998)
el-'Amarna	Amar-	New Kingdom	1350-1370BC	Renfrew (1995)
Timna	Timn-	New Kingdom		Kislev (1988)
el-Hibeh	Hibe-	Late Dynastic - Ptolemaic	1st millennium BC	Wetterstrom (1984)
Karanis	KarnRom	Roman	late 3rd - early 5thCAD	Leighty (1933); Bartlett (1933)
'Ayn-Manawir	Manaw-	Roman	5th C BC - 2nd C AD	Newton, C. 2002
North Kharga Oasis	Khar-	Roman	3rd-4th C AD	Clapham & Dorri (*unpubl.*)
Kellis, Dakhla oasis	Kell-	Roman		Thanheiser, U. 2002
Berenike	Bern-	Roman	275BC -early 6thC AD	Cappers (1999; 2006)
Mons Claudianus	MonsC-	Roman	late 1st - 2nd C AD	Van der Veen (2001)
el-Nana	Nana-	Byzantine	5th-early 7th century	Smith (2003)
Epiphianus	Epip-	Coptic	7th century AD	Winlock and Cram (1926)

Table 7.5 The Nubian and Sudanese Nile Valley sites included in the database with date ranges given where available.

Site Name	Phase code	Period	Date Range	Publication
Toska West		Neolithic		Fuller, *unpubl.*
Semna	Semn-	New Kingdom	1500-1480 BC	van Zeist (1993)
Kawa	Kawa-	Napatan	1^{st} Mil BC	Fuller, 2004
Qasr Ibrim	Ibrim-	Napatan - Medieval	7thC BC - AD850	Clapham & Rowley-Conwy (forth)
Soba East	Soba-	Post-Meoritic - Medieval	c.1000AD?	Van der Veen, (1991b); Cartwright (1998)
Nauri	Naur-	Christian	c.1000AD	Fuller & Edwards (2001)

Table 7.6 The Sahelian sites included in the Database.

Site Name	Country	Phase code	Period	Date Range	Publication
Birimi	Ghana	Biri-	Late Stone Age/ Neolithic	4th Mill BP	D'Andrea, Klee & Casey (2001)
Gajiganna	Nigeria	Gaji-	Stone Age	1800BC – 800BC	Klee & Zach (1999)
Kursakata	Nigeria	Kurs-	Late Stone Age – Iron Age	1000BC-100AD	Klee, Zach & Neumann (2000)
Mege	Nigeria	Mege-	Late Stone Age - present	1000BC- 20th CAD	Klee & Zach (1999)
Daima	Nigeria	Daim-	Islamic/Early Medieval	550BC-cAD1150	Connah (1981)
Oursi	Burkina Faso	Ours-	Late Stone Age – Early Iron Age	c.1000BC – c. 200AD	Kahlheber, Albert & Hohn (2001)
Saouga	Burkina Faso	Saou-	Medieval	10-11th C AD	Kahlheber, S. 1999

Data is entered by site and phase rather than sample (see fig. 7.1 for data model). Each site has a code and each site phase has a separate period code (e.g. Jarma5 or CarthRom). For Jarma phase codes are as throughout this thesis (Jarma10-7; Jarma 6 etc). Where counts were available the total counts and ubiquity (% of samples per phase in which a taxon is present) of each taxon and plant part (seed, rachis etc) is entered by each major cultural phase. Where detailed sample information was not available species presence is recorded as 1. Each entry therefore consists of plant part (seed, glume base etc) per taxon per phase with the combined total of that plant part/taxon for that phase. A total of 4187 entries have been made, consisting largely of charred or desiccated remains with some waterlogged and occasionally mineralised remains or ceramic seed impressions. Sites for which there were multiple excavations and detailed phases have been condensed to major phases (particularly for Carthage for which there were 24 separate phases/excavation areas reduced to 9 period phases). In the case of Carthage which has been the subject of multiple excavations more detailed data was entered in a separate table. For detailed records by sample the reader is directed towards the original report. All publication details and context information is included in the database.

The level of identification was extremely variable reflecting the poor preservation at many sites, the difficulties of identification of many of the grasses for example, or the lack of familiarity with the flora generally in such a new subject. The differing levels of identification are expressed in the taxa table, but are combined with codes (e.g.

Chenopodium cf. *murale* and *Chenopodium murale* are combined as Chemur) (the taxa used in the correspondence analysis below are listed in appendix nine). A more straight-forward approach would be to enter each taxa separately and give a separate code for the level of identification. However, the use of standard codes is used to simplify the data and therefore enable entries to be made according to how they are recorded by each archaeobotanist. Where archaeobotanists have used their own codes for recognisable but as yet unidentified taxa these have been entered as discrete records. Items identified to species, genus, tribe or family are recorded separately resulting in 673 items in the taxa table. A further 57 unidentified taxa were given separate identification codes by the archaeobotanists and are included in the data base but not any subsequent analysis.

During the course of multivariate analysis it was decided to give a second code to enable easy condensing of the data to allow for variation in levels of identification between different sites. This is particularly the case for some of the small-seeded grasses identified to type. For example *Setaria/Brachiaria/Echinochloa* sp, *Setaria* sp. and *Setaria/Brachiaria* sp. are combined by Code 2 to 'Set/Bra' (*Setaria/Brachiaria/ Echinochloa* types). Where items were identified more fully the species identification is retained, so *Brachiaria ramosa/deflexa* remains Brarem/def and is not amalgamated under Set/Bra, although *Brachiaria ramosa* and *B. deflexa* are combined.

As yet ecological data has only been included for some of the taxa. For the purpose of the current study ecological data was compiled for those species which figured strongly in the multivariate statistics (see below) and for those identified from Jarma. It is a future aim to compile an ecological table for the database. There are obvious problems when compiling ecological data for weeds over such a vast geographical area. Many of the arable weeds occur outside their natural habitat and will therefore behave differently. No single flora covers the entire area and the various floras provide varying levels of detail. Given the significant difficulties in assigning ecological characteristics any ecological analysis was limited to a very basic level. Broad habitat groups only are given (arable weed, plant of waste ground, steppe/ desert species, species of wet ground or irrigation channels, and unknown/catholic). Seasonality is given (summer or winter crop, summer or winter weed). Habitat and seasonality are given in appendix nine for all taxa used in the analysis.

7.3 Agriculture in Northern Africa: the Current Evidence

A full discussion of agriculture in North Africa is not possible here and several reviews are available (eg. Neumann 2003; Wetterstrom 1988; Murray 2000a/b; Germer 1985). The following is intended to provide a brief outline of the current evidence and some key issues while the history of key crops is discussed in greater depth. Particular focus is given to issues raised during the course of this study including those subsidiary sites examined in Libya and Morocco. The most obvious problem in both any overview and any numerical analysis of the data is the gaps, both geographical and temporal. Over the past 15 years the number of excavations involving systematic sampling and flotation techniques for the recovery of botanical remains has increased dramatically. As figure 7.5 demonstrates there are still gaps in the data, in particular in the Sahara itself. As the overview demonstrates the new data from the Fazzān is sufficient to quite dramatically alter the known history of some key crops. It can only be stressed that further sampling is critical to fully understand the history of these crops including targeted research where possible.

7.3.1 The Origins of Agriculture in Northern Africa

7.3.1.1 The Sahara and Sub-Saharan Africa

Evidence for the pre-agricultural exploitation of plants, particularly the grasses is provided by data from the Egyptian oasis sites (Wasylikowa *et al.* 1993; 1995; 1997; Wasylikowa 1997; Wasylikowa and Dahlberg 1999; Barakat, & Fahmy 1991; Barakat and Fahmy 1991) and the Fazzān rock shelters (Mercuri 2001; Wasylikowa 1992; Castelletti *et al.* 1999; Wasylikowa 1992). Of significance to the current study is that the grasses exploited in the Fazzān in the Neolithic period do not include significant quantities of wild *Sorghum* or *Pennisetum*, but are dominated by genus such as *Echinochloa*, *Brachiaria*, *Setaria*, *Cenchrus*, *Dactyloctenium*, *Echinochloa* and *Panicum*. Caryopses of wild *Pennisetum elatum/setaceum* type are present at Uan Muhuggiag and Ti-N-Torha/Two Caves only (Wasylikowa 1992), while *Sorghum* sp. is not recorded at any of the Fazzān sites. There is no evidence therefore for any local domestication of these important Sahelian crops. The identification of pollen of *Pennisetum* sp. from Amekni and Meniet in the central Sahara (Camps 1969; Hugot 1968) has frequently been cited as evidence for agriculture (e.g. Harlan 1992; Smith 1998), but is now generally regarded as invalid given the pollen of wild and cultivated forms cannot be distinguished. The three pre-arable Neolithic sites in the south western desert of Egypt, Napta Playa (Wasylikowa *et al.* 1993; 1995; 1997; Wasylikowa 1997; Wasylikowa and Dahlberg 1999), Abu Ballas, Eastpans and Farafra, Hidden Valley (Barakat and Fahmy 1991), conversely all provide evidence for the exploitation of wild *Sorghum.*

The origins of cultivated of pearl millet (*Pennisetum glaucum*), the major crop of the Sahelian zone to the south of the Sahara, are very much associated with the origins of agriculture in sub-Saharan Africa. For a review of the current evidence and a discussion on the late date for agriculture in sub-Saharan Africa see Neumann (2003; 1999). There is general agreement that pearl millet was domesticated somewhere along the south-western fringes of the Sahara by the early 2nd millennium BC (Harlan 1971:470-71; Brunken et al 1977:173; Tostain & Marchais 1993: 41-7; Amblard and Pernès 1989, Neumann 1999 and Klee et al 2000). Finds of domesticated pearl millet have been dated to the early-mid 2nd millennium BC from a region stretching between southern Mauritania, at the sites of Dhar Tichitt, Oualata and Dhar Nema (Amblard & Pernès 1986; Amblard 1996; MacDonald, Vernet, Fuller & Woodhouse 2003), and as far south as Birimi, 1000km to the south in Northern Ghana (D'Andrea, Klee and Casey 2001). None of these sites has produced evidence for in *situ* domestication; the implication being that pearl millet arrived from elsewhere in a domesticated form. Finds of domesticated pearl millet in India from the early 2nd millennium BC (Fuller 2003) further suggest a some-what earlier date for initial domestication.

Slightly later dates have been generated for northern Burkina Faso, where two sites, Tin Akof and Oursi, have produced dates between 1200 and 1000 BC. Agriculture in the Lake Chad region is first attested at a similar date to those from Burkina Faso, with pearl millet recorded from Kursakata and Gajiganna, NE Nigeria (Klee, Zach and Neumann 2000; Klee and Zach 1999). The fact that fully domesticated *P. glaucum* is present from the earliest deposits at Gajiganna lead to the interpretation that it was originally domesticated elsewhere and arrived in the Chad basin with people migrating to the area from the south-central Sahara in the first half of the 2nd millennium BC, as suggested by the associated material culture (Breunig and Neumann 1999b).
Recent isozyme studies of wild populations and domesticated varieties of *Pennisetum* have identified two foci of early domestication, Mauritania and the area of Lake Chad

(Tostain 1998). The archaeobotanical and isozyme evidence therefore suggests two or possibly three regions of domestication before c. 1800 BC, presumably in the south western Saharan region of Mauritania/ Northern Mali and in Niger, which then spread into the Niger River and Lake Chad regions. Prior to these early *Pennisetum glaucum* finds, only wild grasses have been identified from Saharan sites. The domestication of *Pennisetum* and the beginnings of sub-Saharan African agriculture therefore appear to be associated with the final desiccation of the Sahara and associated migrations south.

7.3.1.2 Egypt

The earliest evidence for agriculture of domestic crops in Africa dates from the 5th millennium BC and comes from the Fayuum basin, Merimde Beni-Salama on the Nile Delta and El-Omari near Helwan, south of Cairo (Barakat 1990; Hassan 1985; Ginter and Kozlowski 1986; Caton-Thompson and Gardner 1934; Percival 1936; Täckholm and Drar 1941; Wetterstrom 1993). Detailed discussions of the origins of Egyptian agriculture and a chronological framework are given by Wetterstrom (1985; 1993), Butzer (1976) and Hassan (1984; 1986; 1988). Agriculture appears to have reached Upper Egypt by the early 4th millennium BC (Wetterstrom 1993). Throughout the Egyptian Nile Valley early agriculture is based on an adopted Near Eastern complex in which barley, emmer wheat and flax were the staple crops, supplemented initially by a generalised foraging subsistence strategy relying heavily on wild mammals, plants, fish and wildfowl (Wetterstrom 1993; Hassan 1984a).

By the beginning of the Pharonic period (BC) agriculture was well established in Egypt and has been well studied in detail from artistic, textual and archaeological sources as well as archaeobotanical remains. Overviews of the archaeobotanical evidence are provided by de Vartavan and Asensi Amorós (1997) and Murray (2000a; 2000b), and of the brewing and baking activities by Samuel (2000). Emmer, barley and flax, continued to be the major crops until the widespread adoption of free-threshing wheat during the Hellenistic period. Emmer was primarily used for bread, and barley for beer (Samuel 2000). Murray (2000a) suggests that while free-threshing wheat must have been known to the Pharonic Egyptians, the cultivation of emmer was so ingrained in the Pharonic culture and system of wages and taxation as well as tradition, religion and taste that free-threshing wheat did not become significant until the conquest of Egypt by Alexander in 332BC. Winter pulses are recorded from the

Neolithic onwards, particularly lentil known from pre-dynastic sites (Thanheiser 1992a; 1992b), but also peas, fava/fûl bean and possibly chickpea (e.g. 18th Dynasty Deir el-Medina, Darby *et al.* 1977; Germer 1985) and fodder crops including fenugreek (Germer 1989; de Vartavan 1990; Hepper 1990; Renfrew 1985). The range of fruit remains appears to have expanded by the early Dynastic period when grape and fig pips begin to appear in the record (e.g. at Tell Ibrahim Awad, Thanheiser 1992b). Thus a basic suite of Near Eastern cereals and pulses appear to have been established by the beginning of the Old Kingdom (2900BC), while a range of fruits, condiments and minor crops appear in the record for the first time during the course of the Pharonic period (e.g. Murray 2000b; Germer 1985).

7.3.1.3 Nubia/Sudan

In the Sudanese Nile Valley, despite sieving programmes, the plant remains recovered from Neolithic (c.6000 BP - 4000 BP) and earlier settlements have so far been limited to hard fruit stones of *Celtis integrifolia* (African hackberry) and *Zizyphus spina-christi* from Abu Darbein and El Damer, dated to c. 8500-7799 BP (Abdel-Magid 1989) and Kadero, 18km north of Khartoum (Barakat 1995b). It is possible that conditions up until the 4th millennium BP were too damp and open for preservation of more fragile seeds. Plant impressions in pottery provide evidence for the exploitation of wild grasses including *Digitaria* sp. from 6th millennium BC Shabona, to the south of Khartoum (Stemler 1990) and wild *Sorghum* from Kadero and El Kadada (Stemler 1990), Shaheinab, El Zakiab and Um Direwia (Haaland 1984), Rabak (Abdel-Magid 1989) and Jebel et Tomat (Magid 1989). Other impressions at Kadero include a seed of *Citrullus* cf. *lanatus* (possible watermelon) and *Celtis* fruit stones (Stemler 1990). Outside the Nile Valley evidence for the exploitation of wild grasses and fruits continues into the 3rd and 2nd millennia BC. A cave and midden site at Shaqadud dating to 4200-3500 BP on the Butana Plain on the eastern edge of the Sahel zone (Abdel-Magid 1989), to the east of the Nile (Marks 1984) produced hard fruit stones (*Grewia tenax,* a savanna tree, and *Zizyphus* sp.) and charred grain of *Pennisetum* sp., *Panicum turgidum* and wild *Sorghum*, and desiccated *Setaria* grain (Abdel-Magid 1989). Seed impressions from the Gash Delta in eastern Sudan included a possible domestic sorghum grain (*Sorghum* cf. *bicolor*), dating to the 2nd millennium BC (Costantini, Fattovich *et al.* 1983) although both the identification and the date are dubious.

Despite the exploitation of wild grasses, including wild sorghum, evidence for domesticated crops suggests early agriculture in the Nubian Nile Valley was based on wheat and barley, as it was in Egypt. Barley deposits have been recovered from 5th millennium BC Neolithic graves at Kadruka, near Kerma (Reinold 2000) in the Dongola Reach. In Lower Nubia wheat and barley have been identified in A-Group (c.3100-2780BC) contexts (Lal 1967), while charred barley grains were identified in C-group (300-2500BC) graves at Toska West (Fuller, unpublished data; Fuller 2001). A pre-Kerma (pre 25000BC) deposit within a storage pot from Sai, near Kerma, in the Dongola Reach (site 8-13-52 A, Cat No. 53, Welsby and Anderson 2004) included spikelets of *Triticum dicoccum* and *Hordeum vulgare* as well as seeds of *Citrullus colocynthis* with a desiccated gerbil. While the *Citrullus* seeds may represent hoarded stores of the gerbil, their presence in a storage jar with cereal grain does suggest they had been deliberately stored. A range of fruits were recovered in the foundation deposits of two temples at Semna in northern Sudan as part of the Aswan Dam rescue project in the 1960s dating to 1500-1800 BC (van Zeist 1983). *Vitis vinifera* (grapes), *Zizyphus spina-christi*, *Citrullus vulgaris* (watermelon), *Phoenix dactylifera* (date) and *Ficus carica* (fig) were identified as well as the edible tubers of *Cyperus esculentus*. The fruits and tubers of this species are well known from sites within Egypt by this period and could have been transported some distance along the Nile, thus the significance of their presence as temple deposits in terms of local agriculture is difficult to judge. Agriculture then appears to have been established in the Nubian Nile Valley by the 5th millennium BC, based on emmer wheat and barley as well the perennial fruits grape, fig and date, suggesting a fairly rapid spread southwards from Egypt. Exploitation of wild grasses appears to have continued in areas away from the Nile Valley, but importantly, there is no evidence for the domestication of the African cereals at this time.

7.3.1.4 The Northern Maghreb: Agricultural Beginnings in the Phoenician/Hellenistic Period?

No evidence for arable agriculture is available in the Maghreb or the central Sahara until the 1st millennium BC. In the northern parts of the Maghreb (north of the desert) there is no archaeobotanical evidence for arable farming prior to the arrival of the Phoenicians or Greeks. Much of the region is pastoral or relies on mixed transhumant lifestyles today, particularly in the high ground. Indeed Herodotus describes the pastoral tribes along the Libyan coast between Egypt and Lake Tritonis (bk 4 168-181; 188) who live on meat and milk. In contrast he appears to describe typical oasis cultivation in 'the great belt of sand' to the south which he places between Thebes in Egypt to the Pillars of Heracles (bk 4 181). While agriculture must have been known in many areas of the Maghreb and particularly in the oases, it is possible that much of the region remained largely pastoral until the arrival of the Greeks and Phoenicians.

Two sites have produced archaeobotanical data for the Phoenician/Hellenistic period: Carthage, the major port of northern Tunisia from the Phoenician to Medieval periods, traditionally founded in 814BC (Hoffman 1981; Van Zeist 1994; Ford and Miller 1978; Van Zeist *et al.* 2001; Stewart 1984) and Eusperides, Benghazi in Libya (Pelling and el-Hassey 1998; 1997) occupied from 515BC to the mid-3rd century BC (Buzaian and Lloyd 1996). At both sites agriculture was based on wheat and barley, with grape and fig, supplemented by occasional legumes and minor fruits. Barley and grapes were particularly common at Eusperides, also noted in more recent excavations at the site (Alys Vaughan-Williams *pers. comm.*). A very obvious characteristic noted of the grape pips during the analysis of the Eusperides samples, and again noted by Vaughan-Williams (*pers. comm.*) is that they were particularly short and broad. The length:breadth index (L/Bx100) of the seeds ranged from 56 to 88. This is well within the range given by Stummer (1911) for wild grape (54 to 83), even taking into account the affects of foreshortening due to charring (Smith and Jones 1990). The range given by Stummer for cultivated grapes is 44 to 64. A similar shape was noted amongst modern grapes from Cyrene, which from a limited population of 30 fresh seeds produced a range of 60 to 80. While this is not a satisfactory method of distinguishing wild from cultivated grape (Smith and Jones 1990) it may be useful to characterize particular populations and does suggest that the populations of Cyrenaica, both ancient and modern display a trend towards unusually short and broad seeds. Cyrenaica is outside the geographical region of wild grapes given by Zohary and Hopf (1994) which covers the northern Mediterranean and the Mediterranean coasts of Morocco and Algeria, but excludes most of Tunisia, Libya, Egypt and southern Israel/Gaza. The grapes given to the author in Cyrene were certainly cultivated and were used for the local manufacture of wine, thus it would seem that this is a local characteristic that has persisted for some 2500 years, yet is very different from grapes recovered elsewhere in North Africa, possibly indicating a different route of introduction for the Cyrenaican grapes from the Fazzān grapes for example.

A much broader range of cultivated plants have been identified from Carthage, reflecting the importance of the site as a port and administrative centre. The wheat grains recovered from Punic (Phoenician) levels were dominated by *Triticum aestivum/durum* type with a few grains of *Triticum dicoccum*. Pulses included most commonly lentil, but also bitter vetch (*Vicia ervila*), pea and fûl or broad bean (*Vicia faba* var *minor*). The other major crop plant recovered was olive (*Olea europea*), although the number of stones recovered was small until later periods. A range of minor fruits and condiments were also recovered, mostly Mediterranean crops such as pomegranate, almond, peach, citron (possibly lemon), mulberry, aromatic herbs including coriander, rosemary, and fennel, as well as rare species including sesame (*Sesamum indicum*, represented by a single pollen grain), hazel nut (*Corylus avellana*) and stone pine (*Pinus pinea*), both of which must represent imports and a single pollen grain of *Ricinis communis* (castor).

7.3.2 Agricultural Expansion

7.3.2.1 The Maghreb

The Roman period in the Maghreb is one of known agricultural expansion and increased scale of production with export of grain to Rome in the form of the *annona* (corn tax). Considerable archaeological evidence and documentary material is available which provides a good understanding of technology, how the landscape was structured and how native populations exploited the new markets of the Roman world. For example, archaeological survey in Tripolitania has revealed the vast scale of olive cultivation and olive oil production (e.g. Mattingly 1995, 138-152; Barker *et al.* 1996).

Archaeobotanical datasets are available from the pre-desert region of Tripolitania studied as part of the UNESCO Libyan Valleys Project region of both Roman and Byzantine date (Van der Veen 1985; Van der Veen, Grant and Barker 1996). Data is also available from the Roman ports and urban centres of Carthage (Hoffman 1981; Ford and Miller 1978; Van Zeist *et al.* 2001); Leptiminus in Tunisia (Smith 2001; Jezik 2000) and (limited) Lepcis Magna in Libya (appendix six). Two Roman sites in Algeria have also produced data: Late Roman and Islamic Setif (Palmer 1991) and

Lambesis (appendix eight, very limited data). Together these datasets provide a useful starting point for understanding agricultural production in this period as well as supply to and plant use within the urban and military centres. While the quantities of material recovered from the sites is variable, they do tend to display some similarities in the range of crops recovered suggesting that a varied and well balanced diet was available even within the southern Tripolitania pre-desert region. It is not possible to establish if the range of crops represents a real increased diversity from the proceeding period, although many of the plants represented were present in Punic deposits at Carthage. Until more sites are excavated of late 1st millennium BC date it will not be possible to establish how much the Roman period represents a period of increased crop diversity or the adoption of a richer diet outside the major urban centres.

At all the Roman period sites in the Maghreb free-threshing wheat had replaced emmer wheat. In Egypt this shift from emmer to free-threshing wheat is associated with the Hellenistic period (Crawford 1979). It is not possible to establish at this stage if the change in wheat is associated with Roman administration or if it had occurred earlier. In the Fazzān there is limited evidence of bread type wheat in the late centuries BC at Zinkekra (Van der Veen 1992) and Jarma suggesting it was at least known in the region, although it is not yet clear how widespread its cultivation was. In Tripolitania two free-threshing wheat species are recorded: *Triticum durum* (durum wheat) and *Triticum aestivum* (bread type wheat) (Van der Veen, Grant and Barker 1996, 254). *T. durum* is tentatively identified at Lepcis Magna (appendix six). Elsewhere it does not conclusively appear until the Islamic period, when it is recorded at 10th century Setif (Palmer 1991). The Fazzān data suggests it may have been present at Jarma from the Classic Garamantian (Roman) period. While the early history of *Triticum durum* is unclear it appears that it was introduced in to at least some parts of the region in the Roman period and can not therefore be regarded as an Islamic introduction as suggested by Watson (1983) and frequently cited in the secondary literature.

The expansion of olive production in parts of the Maghreb, particularly Tripolitania and coastal Tunisia, is well attested by the presence of olive presses and amphorae production (e.g. Barker *et al.* 1996; Mattingly 1988; 1994; 1995; 1996). While olive stones were recorded from most of the sites sampled in the Libyan Valley Survey's area, the actual numbers were surprisingly small despite the archaeological evidence for large scale production of olive oil (Van der Veen, Grant and Barker 1996). This might be a result of bulk pressing, or might be the result of secondary uses of the pressing waste. Further evidence is provided by deposits of burnt olive stones and pressing waste at Leptiminus which appear to be derived from the spent fuel of amphorae kilns (Smith 2001; 1999). Large deposits of burnt stones interpreted as the remains of fuel have also been recovered from Setif (Palmer 1991) and Carthage (Van Zeist 1994, 325). The author identified a large deposit of burnt olive stones recovered from a cistern or storage bin at the coastal site of Tocra, Cyrenaica, (shown to the author while on fieldwork in Benghazi in 1996), while large deposits of burnt olive stone were also recovered from Lepcis Magna (appendix six). Not only do these deposits suggest the use of crop processing residue, thus implying organised agricultural practices and possibly a trade and/or transport of such waste into urban sites, but in the case of the Leptiminus material they also suggest deliberate selection of a particular fuel type for particular purposes. Olive pressings are used for fuel in current day pottery production in Tunisia (Sethom 1964, 54-55) and Greece (Matson 1972, 219) due to its specific heat giving qualities with little ash production. In the early to mid 20th century local farmers in Tripolitania could buy back spent olive stones from the municipal presses and press them repeatedly for the extraction of additional oil or for the manufacture of other products such as soap (Moammar Ghouma *pers. comm.*). It is possible therefore that there was much secondary trade in the waste products of olive pressing and certainly it appears to be a widely used source of fuel. The evidence from the Fazzān suggests whole fruit were reaching Jarma by the Classic Garamantian period (see chapter 5), further suggesting some olives were being set aside for culinary use rather than for whole scale oil production. Olive stones recovered from Roman period deposits at Mons Claudianus in the Egyptian Eastern Desert suggests it was also used there as a food rather than oil as olive oil was imported separately in the many amphorae on the site (Van der Veen 2001, 197). The culinary tradition of eating olives (inedible without being pre-treated) may date from this period and was apparently widespread.

A range of Mediterranean pulse, oil, herb/vegetable and both cultivated and wild fruits are represented in the Roman period assemblages from the Maghreb. Pulses recorded include peas, lentils and fodder pulses (grass pea, bitter vetch), while oil crops include flax, safflower, castor oil, opium poppy and of course olive. Herb or vegetable plants recorded include fennel, dill, celery, rosemary, chicory (*Cichorium intybus*), carrot (*Daucus* sp.) and purslane (*Portulaca oleracea*). Cultivated fruits recorded are dominated by fig and grape but also include almond (*Amygdalus communis*), pomegranate (*Punica granatum*) and peach (*Prunus persica*), all of which could have been cultivated in the northern Maghreb, possibly the source of these fruits recovered at Jarma. Dates are only recorded from the Libyan Valleys survey sites at this period (Van der Veen, Grant and Barker 1996). Given the potential value of date fruit this is interesting and may be related to the trade in date pulp/flesh rather than whole fruits (the fruits are commonly stored as blocks or balls of flesh rather than fruit in the Fazzān today). More unusual products recovered from Carthage suggest the import of potential 'luxury' items into the urban centre of north Africa, including stone pine (*Pinus pinea*), hazel nut (*Corylus* sp.), walnut (*Juglans regia*) and mulberry (*Morus nigra*). There is as yet no evidence for these imported goods reaching the Fazzān suggesting perhaps that some 'luxury' food items were particularly precious. This is further suggested by the finds of stone pine and grape pips in grave deposits at Leptiminus interpreted as deliberately placed deposits (Smith 2001).

Stone pine is rarely recorded in North Africa, being recovered from Carthage and Leptiminus only in the Maghreb, and occasionally in Egypt (e.g. Kellis: Thanheiser 2002; Berenike: Cappers 1999; 2006; Mons Claudianus: Van der Veen 2001). While it was presumably imported in part for culinary reasons a number of finds from sacred features and burials across the Roman Empire suggest it to have had some ritual or religious significance. Of the 25 sites Kislev (1988) lists where stone pine has been recorded, nineteen were from countries where the tree is not native, mostly Egypt and Britain. A number of finds of pine cone, nuts and/or nut kernels have been found as offerings throughout northern Europe including the Temple of Isis, in Mainz, Germany (Zach 2002), a 2nd century AD temple to Fortuna at Noviomahus (Nijmegen), the Netherlands (Hannien and Vermeeren in Robinson 2002), and in Britain at Roman temples in London and Verulamium (Kislev 1988), and Carrawburgh on the Antonine Wall (Richmond and Gillam 1951, 86-87) and a pit from a Romano-British shrine at Rochester (Monckton 2000) which also included dates. Finds from burial contexts also exist including the remains of a possible funeral pyre of a late 1st or 2nd century AD high status burial in London which included fig, date and a domestic fowl (Giorgi in Mackinder 2000, 10-12). Within Italy deposits of stone pines burnt as offerings have been recovered from both public and domestic ritual contexts at Pompeii (Overbeck and Mau 1884, 108-9; Robinson 2002), and from the buildings of the Vestal Virgins in the Forum at Rome (Costantini and Giorgi in Robinson 2002). The overseas trade in Italian cones is known from a Roman ship-wreck near Toulon, France (Kislev 1988), indicating that stone pine was commonly traded around the Empire and may have been of particular significance to the military.

7.3.2.2 Egypt: the Nile and Beyond

In Egypt the Hellenistic period, following the conquest of Egypt by Alexander the Great in 332 BC and the subsequent Roman period following the death of Cleopatra in 30 BC, are regarded as periods of great agricultural innovation both in terms of species introduced and irrigation technology employed. Few sites of Hellenistic date have been systematically sampled, so much of our knowledge of this period derives from historical documents, particularly papyri, and tomb paintings. An overview is given by Crawford (1979). Ptolemaic policy was to increase agricultural production, and innovations in farming were largely the result of royal patronage, particularly during the reign of Ptolemy II Philadelphus (285-246 BC). Extensive irrigation and reclamation works were undertaken of which the greatest information available is from the Fayuum basin (Crawford 1971, 39-42) from where several papyri have been recovered, in particular the papers of Zenon, the manager from 256-247BC of Ptolemy II's finance minister, Apollonios', estate at Philadelphia. The cultivated land here was almost trebled (Butzer 1976, 47) and new crops were introduced. Innovations in plant culture include the introduction of new species but also of new strains of existing species such a garlic (Crawford 1973) and chickpeas (P. Cairo Zen. 59731 = P. Col. Zen. 69, 14, 16, 21). Viticulture was much extended due to the Greek taste for wine, rather than beer, as was the cultivation of other fruits such as figs, walnuts, peaches, apricots, plums and olives (Préaux 1947, 22-7). The most significant change was the wide scale adoption of a free-threshing wheat, replacing emmer, the staple of the Pharonic period. The free-threshing wheat is widely regarded as *Triticum durum* (hard wheat) (Crawford 1979). This belief, however, appears to have been based on assumption that durum is the only naked wheat reported from Ptolemaic sites in the adjacent Fayuum rather than on rachis morphology (Wetterstrom 1984, 54). A review of free-threshing wheat rachis morphology is needed for this period. Emmer wheat continued to be cultivated but in decreasing amounts (Schnebl 1925) and by this period was mostly associated with temple communities (Crawford 1979). The first abundant evidence for the cultivation of olive dates from the Ptolemaic period (Täckholm 1961; Darby *et al.* 1977; Newton *et al.* 2005) prior to which olive oil is generally believed to have been imported from Palestine (Täckholm 1961, 28) and any local cultivation was minimal, associated with the temples and royal house (Haldine 1993).

The Roman period in Egypt is much better represented than the preceding period largely due to a series of recent excavations at oasis sites (e.g. 'Ayn-Manawir: Newton 2002; North Kharga Oasis: Clapham & Dorri *unpubl*; Kellis, Dakhla Oasis: Thanheiser 2001), quarry sites in the Eastern Desert (e.g. Mons Claudianus: Van der Veen 2001; Mons Porphorites: Van der Veen *forth.*) and the Red Sea Ports (Berenike: Cappers 1999; 2006; Quesir al-Qadim: Wetterstrom 1982; Van der Veen 2001b). Archaeobotanical data from the Nile Valley is actually poor for this period, one of the few examples being Karanis, a 3rd-5th century AD urban site in Lower Egypt (Bartlett 1933; Leighty, 1933) while a number of multi-period sites have provided occasional Roman period remains. As for previous periods much of our knowledge of agriculture, food and diet in Roman Egypt is based on documentary or historical evidence rather than archaeobotanical material.

The desert quarry sites and the port sites are exceptional and provide invaluable evidence for trade and commerce in arable and food products. The exceptional preservation at the sites has resulted in the remarkable survival of vegetable parts which are not normally recovered archaeologically. There is consequently a long list of fruit, vegetables and condiments available for this period and their absence from other sites cannot be interpreted with any degree of reliability. The importance of these datasets lies in the fact that this period was clearly one of great mobility of produce, both home grown and imported, with products arriving from as far a field as the Indian sub-continent such as pepper at Berenike (Cappers 1999; 2006) or from the East African coast such as coconut (Cappers 1999; 2006). The reader is directed to the individual site reports for a more detailed account of these remarkable assemblages. Of relevance to the current study is the material recovered from the agricultural oasis centres which offer valuable contemporary comparisons with Garamantian agriculture as well as the history of particular crops which appear during this period in the Fazzān as well as in Egypt and Sudan.

Agriculture at the oases in the Greco-Roman period appears to have been largely based on the Near Eastern Cereals (wheat and barley) and perennial fruits. Both *Triticum aestivum* type (bread wheat) and *Triticum durum* (hard wheat) are convincingly recorded. Occasional records of *Triticum dicoccum* also occur. *Triticum monococcum* has been identified as recorded in the 'Kellis Agricultural Accounts Book' (Wagner 1990) but has not been identified archaeobotanically (Thanheiser 2001). Bread wheat was present at Mons Claudianus in such small proportions in comparison to the hard wheat that it was interpreted as a contaminant rather than a crop in its own right (van der Veen 185). It was not positively identified at Berenike (Cappers 1999; 2006), Karanis (Leighty 1933; Bartlett 1933), Quesir al-Qadim (Wetterstrom 1982) or 'Ayn-Manawir (Newton 2002; Newton *et al.* 2006). Caution should be exercised concerning the identification of free-threshing wheat from Karanis given the date of the publication, although the absence of *Triticum aestivum* at Berenike can be regarded as more reliable. However at both North Kharga Oasis (Clapham *pers. comm.*) and at Dakhla Oasis (Thanheiser 2001) *Triticum aestivum* is present in significant amounts while *Triticum durum* is absent. *Triticum dicoccum* is only ever a rare occurrence, possibly as a contaminant of the *Triticum aestivum.*

In addition to the Near Eastern cereal crops, cultivated *Sorghum bicolor* is recorded for the first time on the Egyptian sites, present at both 3rd/4th century AD North Kharga Oasis and in the 5th and 6th century deposits at Berenike (Cappers 1999; 2006). Sorghum is not however recorded at the earlier oasis site of 'Ayn-Manawir, or at Kellis in Dakhla Oasis. Its absence from the Egyptian Nile Valley north of Nubia (see below for a discussion of sorghum in Nubia) is presumed to be related to the annual flooding of the Nile which would render arable production in the summer months difficult until suitable irrigation technology (i.e. the *saqiya* water wheel) became available. In the oases, the introduction of the *qanāt* (*foggara*) in the mid-late first millennium BC (Wuttmann *et al.* 2000) would have opened up the summer season to arable production as it did in the Fazzān. *Qanāt* irrigation was not used at Dakhla Oasis which may explain the absence of sorghum from Kellis, although summer irrigation would have been required for the cultivation of cotton (see below). The delay in the arrival of sorghum following the introduction of the *qanāt* however would suggest the primary concern of improved irrigation was the winter cereals and perennial fruits. Here it is clear that the introduction of summer crops was a later, separate event to improved irrigation.

Finds of Cotton (*Gossypium* sp.) seed are recorded in Egypt for the first time in this period from Kellis, Dakhla oasis (Thanheiser 2001), and from North Kharga Oasis (Clapham, *pers comm.*). Cotton textiles are known to have been imported into the Red Sea ports (e.g. Wild and Wild 1998), however the presence of cotton bolls and seeds at the oasis sites suggests their cultivation there. The cultivation of cotton is also recorded at Dakhla in the 'Kellis Agricultural Accounts Book' (Bagnall 1997). The cultivation of cotton in Egypt appears to be restricted to the oases at this time and is presumably related to irrigation technology.

7.3.2.3 The Upper Nile: Napatan through to the post-Meroitic periods.

Our knowledge of Nubian archaeobotany is dominated by the remarkably well-preserved material from Qasr Ibrim (Rowley-Conwy 1991; 1988; 1989; Rowley-Conwy *et al.* 1999; Clapham and Rowley-Conwy *forth.*). This is now being complemented by a range of datasets recovered from other sites within northern Sudan as well as a large number of spot finds and museum acquisitions from excavation finds, particularly cemeteries. A full review of Sudanese archaeobotanical remains has been compiled by Fuller (unpublished data). The discussion here is limited to the better sampled sites and significant occurrences of certain crops. The dominance of Qasr Ibrim has been particularly relevant in the understanding of the early history of sorghum, although it may obscure data from other sites. In the Medieval period the data is represented with the well sampled sites of Soba and Soba East, Khartoum (Van der Veen 1991b; Cartwright 1998). Recently new data pre-dating Qasr Ibrim has been generated by excavations at both the third and fourth cataracts which add significantly to our understanding of early Meroitic or pre-Meroitic agriculture and particularly of the history of sorghum cultivation (Fuller 2004a; Fuller 2004b; Fuller and Edwards 2001).

Evidence for the first millennium BC, Napatan (8^{th} -5^{th} century BC) period agriculture is derived from Qasr Ibrim (Rowley-Conwy 1991; 1988; 1989; Rowley-Conwy *et al.*

1999; Clapham and Rowley-Conwy *forth.*) in the north of the region and Kawa in the Dongola Reach (Fuller 2004a). Agriculture appears to have been similar in character to that of Pharonic Egypt with emmer wheat and barley being the staple crops, supplemented by pulses (mostly lentil) a range of fruits including grape at Kawa, but not Qasr Ibrim, oil and fibre crops and spices. A sequence of sorghum grain at Qasr Ibrim begins in the Napatan period during which only wild varieties are recorded. At Kawa, however, grains and a rachis fragment of possible domesticated sorghum include a grain directly dated to 2450 +/- 40 BP (Beta-194234) or calibrated date of 780 to 400 BC (Fuller 2004a). The sorghum grain is plump with a fattened profile and has been identified as race *caudatum* or *durra* type. The significance of this is discussed in more detail below. Small millets at both sites may also represent summer crops, *Panicum miliaceum* (broomcorn millet) and *Setaria sphaceleata* at Kawa and possible *Setaria italica* at Qasr Ibrim. Irrigation at this time was by the *shaduf* which would have been highly labour intensive although effective for garden crops such as grapes. There is artefactual evidence for an apparent episode of wine production in Nubia, although generally short lived in the 6th century BC (Macadam 1949), despite open trade with Egypt, and again at the close of the Meroitic period when there was an interruption of trade with Egypt (Adams 1966).

The Roman and Meroitic periods in the first half of the first millennium AD represent a period of accelerated agricultural change at Qasr Ibrim in which a range of new crops appears (Rowley-Conwy 1989; 1991; Rowley-Conwy and Clapham *forth.*). This period of change may actually begin slightly earlier in the Late Napatan or Ptolemaic period, which is supported by some new dates (Alan Clapham *pers. comm.*) although a gap in the chronology exists obscuring the sequence. Free-threshing wheat is first recorded in the Roman period (?25BC to 100AD), initially *Triticum durum*, but including *T. aestivum* by the later Meroitic period (300 - 400 AD). Other major crops which are now known to appear for the first time in the Roman deposits include cotton, of which capsules of *G. herbaceum* have been provisionally identified, and grape as well as summer cereals. Cotton seeds have now been AMS dated to the late 1st century BC/1st century AD (Alan Clapham *pers. comm.*). Cultivated sorghum is also recorded for the first time at Qasr Ibrim, dating to the Roman period (Rowley-Conwy & Clapham *forth*; Clapham *pers. comm.*) consisting of grain and spikelets of *Sorghum bicolor* race *bicolor*. In addition pearl millet (*Pennisetum glaucum*) is recorded for the first time. In the Meroitic period white lupin (*Lupinus albus*) appears, apparently an important pulse at the site, while two summer pulses, hyacinth bean (*Lablab purpureus*) and pigeon pea (*Cajanus cajun*) are present from the late Meroitic period onwards.

Contemporary sites in Middle Nubia suggest a similar mix of winter and summer crops were being cultivated at least by the later Meroitic period. *Sorghum bicolor* race *bicolor* is also recorded at Jebel el Tomat in central Sudan dated to AD 245 +/- 60 (Clark and Stemler 1975) and Meroë dated to 20 +/-127 BC (Stemler and Falk 1981) as well as possible Late Meroitic deposits on the island of Umm Muri, in the Fourth Cataract (Fuller 2004b). While analysis of material from this site is at an early stage, remains from two samples are providing some indication of other crops present at the site (Fuller 2004b). Winter cereal crops include wheat, probably *Triticum dicoccum* and *Hordeum vulgare*, but as yet no free-threshing wheat. Summer pulses of sub-Saharan origin were also present including hyacinth bean (*Lablab purpureus*) and cowpea (*Vigna unguiculata*). Remains of a *Setaria* species (not *S. italica*) were identified from an Early Meroitic pot in a cemetery at Amir Abdallah, north of Nauri (Fernandez 1983, 1366), which could represent the use of wild species. Further evidence for the cultivation of grapes in the Late Meroitic period comes from mid-fourth century AD deposits at Arminna West in Lower Nubia where grape wood charcoal was identified (Fuller 1999). Finds of cotton cloth have been identified from sites in both Middle and Lower Nubia, from Karanog and Meroë (Crowfoot and Griffiths 1934); Qasr Ibrim (Crowfoot *et al.* 1977; 1979), and several cemetery sites (Mayer Thurman and Williams 1979; Bergman 1975).

Evidence from Roman and Meroitic period sites therefore suggests that the same range of crops, both winter and summer staples recorded at Kawa, as well as demanding crops including grape and cotton, were being cultivated both to the north and south of Kawa by the Meroitic period, presumably as the *saqiya* water wheel became more widely distributed in Sudan. At Qasr Ibrim the characteristic *qadus* pots of the *saqiya* first appear in the Late Meroitic period (Rowley-Conwy 1989). The adoption of *saqiya* technology is likely to be closely related to the adoption of the new suite of crops.

7.3.2.4 The Iron Age in the Sahel: African Rice and Sorghum

Pearl millet continues to make up a significant proportion of the seed data from 1st millennium BC (Iron Age) sites across the Sahel regions, and indeed continues to be the most important crop in the region today. A particularly significant innovation which appears to date to the 1st millennium BC is the domestication of African rice (*Oryza glaberrima*). Evidence from the sites of Dia Mara and Dia Shoma in the Middle Niger Delta indicate that domesticated African rice was present from the earliest deposits (800-500BC) where it formed some 40% of all plant remains in that horizon (Murray 2004). Given the significance of rice, Murray suggests that the economy was based on rice farming from the earliest occupation at the site, pearl millet being a secondary crop at this stage, supplemented by wild grasses (Murray 2004). African rice was also recovered at Jenné-Jeno in the oldest levels, dating about 250 BC, where again it was supplemented by wild grasses such as *Brachiaria ramosa* (McIntosh 1995). Tentatively identified wild rice (*Oryza longistaminata* or *O. barthii*), was recovered in large numbers from deposits at Gajiganna and Kursakata on the edge of Lake Chad, northeast Nigeria, dating 1800 BC to AD 400 (Klee and Zach 1999; Klee *et al.* 2000).

The Niger Delta has long been considered a likely centre of domestication of African rice (Andah 1993; Clark 1976; Harlan 1971; Harlan 1995; Harris 1976; Ogbe and Williams 1978; Portères 1970; 1976; Shaw 1976). While the exact timing and location of its domestication remain unclear the archaeobotanical data generated by recent work such as that at Dia (Murray 2004) is crucial in developing our understanding of the history of this important crop.

The Late Iron Age (1st millennium AD) appears to be a period of agricultural innovation in the Sahel with the first undisputed appearance of cultivated sorghum in the region as well as other crops. Domesticated Sorghum has been identified from Jenné-Jeno in Mali (McIntosh 1995: 349ff) which may date from around the birth of Christ, although dating of the earliest levels is incomplete and the actual timing of the first occurrence of sorghum is unreliable. Grains of race *Caudatum* were present by the early Islamic period (McIntosh 1995). Sorghum grain of the primitive race *bicolor* was identified from 1st millennium AD sites at Daima and Mege (Connah 1981; Klee and Zach 1999; Klee et al 2000) in the Chad Basin of North-eastern Nigeria and from the site of Elkido dated to 250-540AD Magnavita (2002 from Neumann 2003).

Sorghum therefore appears to be absent in the Chad Basin until the 1st millennium AD despite the region being included in Harlan and Stemler's (1976) proposed area of domestication. Sorghum occurs in the second part of the 1st millennium AD in Burkina Faso (Albert *et al.* 2000), northern Cameroon (Otto and Delneuf 1998) and Senegal (Gallagher 1999). As Neumann points out (1999) the appearance of sorghum in the first millennium AD appears to be associated with the appearance of several other crops in West Africa including *Vigna unguiculata*, *Voandzeia subterranea*, *Citrullus lanatus*, *Hibiscus sabdariffa* and *H. esculentua* (Otto & Delneuf 1998; Kahlheber 1999; Albert *et al.* 2000). This, Neumann suggests (1999) indicates a differentiation and intensification of agricultural systems in the Late Iron Age which included the adoption of a suite of new crops. The absence of sorghum prior to these finds is problematic in terms of understanding the early history of this crop and has resulted in the formation of late domestication theories (see below).

7.3.3 The Post Roman Period and the Arrival of Islam: an Agricultural Revolution?

The period following the collapse of the Roman Empire was one of political turmoil in which the relationship of North Africa with the economic markets of the Mediterranean was severely disrupted. Archaeological data is limited for the period following the collapse of the Roman Empire, although some Byzantine data is available. The Late Roman and Byzantine periods saw the decline of the major Roman ports and the silting up of the harbour at Lepcis Magna, while those at Carthage were largely in disuse. As such, deposits from the Late Antique period tend to be more informative about local diet rather than trade. The Arab period has traditionally been regarded as one of agricultural innovation and the spread of several significant crops has been attributed to this period as part of an Islamic Agricultural Revolution (Watson 1983). Most significant during the Islamic period is the growth of trans-Saharan trade particularly in West Africa, which resulted in trade of arable goods if not in the cultivation of new crops.

Both the Libyan Valleys Survey sites (Van der Veen, Grant and Barker 1996) and Carthage (Stewart 1976b; Van Zeist *et al.* 2001) have produced Byzantine period material. At both sites barley and free-threshing wheat, including *T. durum* on the Libyan Valleys sites, are the dominate cereal crops, supplemented by pulses, oil crops and perennial fruits, such as grape, fig, olive, peach, and pomegranate. Some imported goods continue to be present at Carthage such as walnut and stone pine, suggesting some continued trade in perishable goods. In Egypt contemporary material has been examined from 5th to 7th century Byzantine Kom el-Nana (Smith 2003). Here the cereal assemblage included *Sorghum bicolor*, although it has not been identified to race. While Smith does not make any assumption regarding the local cultivation of sorghum it does further add to the number of pre-Islamic sites from which Sorghum has been identified in Egypt (it was also recorded at the Red Sea port of Berenike: Cappers 1999; 2006). On the whole the evidence from all the Late Antique sites suggests a continuation of Greco-Roman traditions, a characteristic also pointed out by Smith (2003). The important innovations may be the northwards spread of sorghum and westward introduction of cotton into the Fazzān.

The Islamic period in the Maghreb is represented by data from Setif in Northern Algeria (Palmer 1991), Carthage (Van Zeist *et al.* 2001; Van der Veen and Van Zeist 1982) and by several sites in Morocco (Pollock 1983-4; Mahoney 2003; Pelling *forth.*, appendix five; Mahoney *unpubl.*; Perry 1999; Fuller, Pelling and De Varailles *forth.*). Hard or pasta wheat (*Triticum durum*) was positively identified at Setif from at least the 10th century AD (Palmer 1991) while bread wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*) were also identified. Two pulse crops were identified: lentil and bitter vetch. Occasional stones of olive were found in the Islamic deposits and may have been cultivated locally, while date identified in 10th-11th century deposits, rare examples from the northern Maghreb, were presumably imported from further south. There is some indication from the weed components that the area experienced a shift from more wooded conditions to a more open environment during the Islamic period (Palmer 1991, 264), however the scale of agriculture could not be established. At Carthage a thick seed-rich layer of ashy soil dated to the 11th-13th century AD produced abundant grain of barley and wild species of disturbed habitats including arable fields (Van Zeist *et al.* 2001; Van der Veen and Van Zeist 1982). The deposit was interpreted as containing the waste of crop cleaning activities indicating that crop processing was taking place within the settlement at this period. Free-threshing wheat, pea, fig and coriander were also identified. At both Setif and Carthage there was weed evidence for in-*situ* cleaning of crops, although at Setif this was interpreted as only the final, late stages of cleaning (Palmer 1991). It never the less may indicate that grain was being traded in a less processed state that in the Roman period when processing waste was rarely reported.

7.3.3.1 Morocco: an Independent Tradition?

The systematic recovery of archaeobotanical remains from sites within Morocco has been very limited until recently. Preliminary sampling of four Islamic urban sites (Badis, Al-Basra, Nakur and Qasr es-Seghir) in 1980 (Pollock 1983-4) has since been supplemented by more detailed sampling at Al-Basra (Mahoney 2003; Pelling *forth.*, appendix five). Further material has been studied from an additional two sites, also Islamic towns, Sijilmasa (Mahoney *unpubl.*; Perry 1999) and Volubilis (Fuller, Pelling and De Varailles *forth.*). Only limited material has so far been recovered from the Roman levels at Volubilis and occasional Late Roman remains were recovered from Al-Basra (Mahoney 2004). One sample of Portuguese period (16th century AD) material has been recovered from Qasr es-Seghir (Pollock 1983-4). The available botanical record is now providing a good picture of the arable economy of Islamic towns in Morocco. The material suggests that while the economy is essentially Mediterranean, the area to the west of the Rif Mountains shows characteristics which are distinct from the rest of the Maghreb. For this reason Morocco is treated separately in this discussion.

Wheat and barley were present at all the sites sampled and clearly form the staple crops as they do in the rest of the Maghreb and Egypt. Unlike the rest of the region however the wheats cultivated include two hulled species: einkorn (*Triticum monococcum*) which has been recorded at Al-Basra (Pelling, appendix five) and Volubilis (Fuller, Pelling and der Varailles *forth.*) and emmer (*Triticum dicoccum*), recorded at all the sites sampled except Sijilmasa, but including Portuguese deposits at Qasr es-Seghir (Pollock 1984; Mahoney 2004; Pelling, appendix five; Fuller, Pelling and De Varailles *forth.*). Elsewhere in the Maghreb emmer is rarely recorded after the Roman period, being present in Byzantine or Late Antique Egypt at Kom el-Nana (Smith 2003), Late Meroitic, Early Christian Qasr Ibrim (Clapham, *forth.*) and possibly Vandal/Byzantine Carthage (Van Zeist 1994; the reliability of this identification in Late Antique contexts here is dubious). Einkorn is only recorded at Al-Basra and pre-dynastic El-Omari in Northern Egypt (Barakat, H. 1990). Thus the cultivation of hulled wheats into the later 1st millennium AD would appear to be a characteristic of Morocco not seen elsewhere in North Africa.

Archaeobotanical finds of einkorn and emmer and ethnographic data indicate that both wheats were cultivated in Spain from the Neolithic onwards, although apparently decreasing in importance, and continued to be so in the earlier part of the 20th century (Buxó *et al.* 1997; Peña-Chocarro and Zapata-Peña 1998). The modern cultivation of einkorn has also been recorded ethnographically in parts of the Rif Mountains in Morocco and in Andalusia in Spain (Peña-Chocarro *et al.* 2000; Peña-Chocarro and Zapata 2003). Thus it would appear that relic populations of einkorn and emmer have continued to be cultivated in parts of Morocco to the present day and their cultivation may have been more widespread in the past. Where einkorn is still cultivated it seems to be primarily for the straw which is used in thatching, while the grain is fed to livestock, especially chickens (Peña-Chocarro *et al.* 2000; Peña-Chocarro and Zapata 2003). It is particularly interesting to find these crops in urban environments in the Islamic period as they are not currently associated with commercial trade, although the local selling of non-commercial crops like *Phalaris canariensis* in towns in Morocco (D. Fuller *pers. comm.*) would suggest that such crops might still enter the local markets even if rarely and sporadically.

As well as the hulled wheats, free-threshing wheat is recorded at all the sites sampled in Morocco so far except Sijilmasa (Pollock 1984; Mahoney *unpubl.*; Pelling, appendix five; Fuller, Pelling and De Varailles *forth.*). Sijilmasa has so far only produced grain of indeterminate wheat species, although this is likely to change with the examination of more samples. The free-threshing wheat present has not been positively identified to species on any of the sites so far, although tentative identification of hard wheat (*Triticum durum*) has been made for early Islamic Volubilis (9th century AD) (Fuller, Pelling and De Varailles *forth.*).

In addition to wheat and barley four other possible cereal or grass crops have been recorded. Broomcorn millet (*Panicum miliaceum*) is another common Mediterranean crop and is the millet of classical times widely cultivated in the Roman period (as *milium*). It was recorded at Al-Basra (Pelling, appendix five; and tentatively by Mahoney *unpubl.*) and Volubilis (Fuller, Pelling and De Varailles *forth.*) and was recorded by Pollock (1984) in her assessment of samples from the four urban sites, although she does not state at which sites it was found. It is a hardy and quick growing crop cultivated in the summer months and completing its life cycle in 60 to 90 days, making it a particularly useful supplementary summer crop. While it has not commonly been identified from North African sites it is known from elsewhere in the Mediterranean basin from the 2nd millennium BC (e.g. Italy, Zohary and Hopf 1994) and wild *Panicum* species also occur in weed floras. Oats (*Avena* sp.) was also recorded as Al-Basra (Pelling, appendix five) and Volubilis (Fuller, Pelling and De Varailles *forth.*) and by Pollock (1984) although again she does not state the sites. Its status as a crop can not be demonstrated without the diagnostic chaff (floret bases) however and it may be present as a weed. The third possible crop is canary grass (*Phalaris canariensis*), although it is also a common weed species. *Phalaris canariensis* was the most consistently identified weed species identified in samples from Al-Basra (Mahoney *unpubl.*; Pelling, appendix five) and was also common in samples from Volubilis (Fuller, Pelling and De Varailles *forth.*). Both its ubiquity at these sites and the large quantities would suggest that it has been deliberately collected and brought into the site if not actually cultivated. As already mentioned, *Phalaris canariensis* has been seen being sold in local markets in Northern Morocco (Dorian Fuller *pers. comm.*) and clearly therefore has some economic significance. Its occurrence in the samples may reflect its use as a livestock fodder, particularly for chickens, or that it was a tolerated impurity in the cereal grain. As with the hulled wheats, its presence in the urban centres may reflect sporadic selling of these crops for chicken feed or when a surplus was available or indeed if other crops were scarce. Finally, rice, *Oryza* sp. has been identified at Volubilis (Fuller, Pelling and De Varailles *forth.*). Rice is likely to represent an import from West Africa, possibly from the Niger Delta region.

Cultivated legumes are recorded at most sites although always rarely and in low numbers. Three species have been identified, lentils, peas and fava or fûl beams. No legumes were record from Nakur (Pollock 1984) although this is likely to be a reflection of the limited sampling at the site. In northern Morocco today pulses are cultivated only as a subsidiary crop (Nuttonson 1961: 131, table 24) and it remains to be seen if this has always been the tradition or if the paucity of legumes is a product of preservation.

The three major Mediterranean fruits, grape, fig and olive have been recovered from sites in northern Morocco. Grape and fig have been recovered from all sites, olive from Qasr es-Seghir (Pollock 1984) and Volubilis (Fuller, Pelling and De Varailles *forth.*). A *Prunus* species, thought to be plum was also identified from Qasr es-Seghir (Pollock 1984), while date is recorded only at Sijilmasa (Mahoney *unpubl.*). The absence of date at any other site would suggest that date was not being cultivated locally but was a traded product.

Three possible textile crops have been identified from sites in Northern Morocco: cannabis (*Cannabis sativa*), recorded from Al-Basra (Mahoney 2003); flax (*Linum usitatissimum*) identified by seed from Volubilis (Fuller, Pelling and De Varailles *forth.*) and a stem fragment from Al-Basra (Perry 1991); and most significantly cotton (*Gossypium* sp.) recorded in large numbers from samples at Volubilis (Fuller, Pelling and De Varailles *forth.*). Two samples of Cotton seed from Volubilis produced AMS dates of 1220±40 BP or calibrated AD 690 – 900 (Beta 194243) and 1130±40 BP or Calibrated AD 790-1000 (Beta 194238). In the absence of earlier deposits it is not possible to establish if cotton was introduced to Morocco by the Arabs, but certainly it appears to have been present by the 8^{th} or 9^{th} century. Historical sources attest to the importance of textile manufacture during the early Islamic period in the area, particularly of flax (al-Bakri 1965, 216) and cotton (Ibn Hawkal 1842, 192), which would suggest that further evidence for textiles may well yet be recovered. The large number of cotton seeds recovered at Volubilis may indicate a fairly significant scale of processing. Presumably the arrival of cotton in the 8^{th} or 9^{th} century is associated with the establishment of a West African trans-Saharan trade network, the raw product being traded northwards where it was processed into cloth. Trade of both raw textile products and some foodstuffs (rice) can be envisaged from an early period of Islamic period trans-Saharan trade.

7.3.3.2 The Sahel and Nubia in the Islamic/Medieval periods

The Christian (AD 550-1200) and Islamic period (AD1200-1800) at Qasr Ibrim are characterised by a reduced rate of agricultural change with few new introductions (Rowley-Conwy 1989; 1986). The most significant development which does appear to be post-Meroitic is the gradual replacement of the sorghum race *bicolor* with that of the race *durra,* the most advanced variety cultivated widely today. Both races appear to have been cultivated in the Late Christian period, but *bicolor* appears to have been completely replaced by race *durra* early in the Islamic period. This localised transition from primitive to more advanced sorghum race has been the basis of arguments for a late domestication based in the Middle Nile region which is discussed further below. Two other new crops which appear during this period are cow pea (*Vigna unguiculata*) and in the later Islamic period maize (*Zea mays*), indicating that Qasr Ibrim remained receptive to new introductions. Cultivated sorghum is also recovered from Soba and Soba East during the Christian period (Van der Veen, 1991b; Cartwright, 1998), although the race is not given, as is pearl millet, suggesting both crops were well established by this time, and also at Nauri in the Dongola Reach (Fuller and Edwards 2001), where cow pea (*Vigna unguiculata*) is also recorded.

While this period in Nubia is considered one of continuation rather than change, new crops are recorded in the Niger Delta region which can be associated with the growth of West African trans-Saharan trade. Early in the 2nd millennium several species occur or increase in significance at Dia, including pearl millet, bread wheat, and cotton which are interpreted as indicating a changing or intensified relationships between Dia and the outside world (Murray 2004). Murray interprets the increased presence of pearl millet in relation to rice as the result of either enhanced trade or exchange with other communities, or the movement of new populations into the area, or perhaps due to the temporary drying out of land in the area previously too wet for pearl millet cultivation. The bread wheat grain identified includes one AMS dated to AD 779-1157, which are interpreted as imported goods, either as trade or brought with travelers (Murray 2004).

Cotton was the most commonly recovered taxon at Dia, identified in large numbers during Horizon 4 (AD 1000-1600). The sudden appearance of abundant remains of cotton seeds and spindle whorls may be associated with the influx of new people already familiar with cotton textile production. Other finds of cotton in West Africa included well preserved textiles from the Tellem burial caves of the Bandiagara (Mali) dating from the 11th -12th century AD (Bedaux, 1991), cotton pollen and associated artifacts (*disques à cordeler*, used in the manufacture of cordage, and spindle whorls) from 11th-century levels at Ogo, in the Middle Senegal Valley (Chavane, 1985) and a seed and seed fragments from Gao (Mali), dating AD 1399-1445 (Fuller, 2000; Insoll, 2000). Historic sources suggest the production of cotton cloth by the 11th century AD (e.g. Levtzion and Hopkins, 2000). Today cotton is mainly grown in the southern part of Mali although Monteil (1927) indicates that cotton can be produced with irrigation in the Middle Niger Delta.

7.4 The Influence of the Sahel: Sorghum, Pearl Millet and Cotton

This section summarizes the evidence for these three Sahelian crops for which the evidence from Jarma and Tinda B is so significant. The plotting of records for these crops provides a history for the crops themselves but may also provide important information about their introduction into the Fazzān and consequently the relationship between the Garamantes and surrounding cultural groups.

Pearl millet (*Pennisetum glaucum*) is present in the Fazzān before it appears anywhere in the Nile Valley. At Aghram Nadharif in the southern Fazzān, *Pennisetum* type caryopsis were recorded in Classic Garamantian (Roman) levels (Mercuri and Bosi 2005) suggesting that it may also be present here. Despite extensive sampling at Qasr Ibrim (Clapham & Rowley-Conwy *forth.*, Rowley-Conwy 1991; 1989), and an increasing body of data from Sudanese Nubia (e.g. Fuller *forth.*; Fuller and Edwards 2001), pearl millet does not appear to be present in Nubia until the Roman period at Qasr Ibrim (Clapham and Rowley-Conwy *forth.*). Similarly it has not yet been recorded at the Egyptian oases. The distribution of pearl millet (fig. 7.2) then would suggest that it was introduced to the Fazzān region from the Sahel regions to the south and south west of the Sahara.

The early history of sorghum is more problematic given the paucity of finds in Africa to date and continued uncertainty about centres of origin (see fig. 7.3 for distribution of find spots for cultivated sorghum). Three hypotheses currently exist about the timing and location of the origins of sorghum. The 'Early Hypothesis' is based on the modern distribution of the wild progenitors and assumes that sorghum was domesticated between 4000 and 2000BC some where between Lake Chad and the Nile (e.g. Harlan 1992a; 1992b). Against this hypothesis is the lack of archaeological finds of cultivated sorghum prior to the beginning of the Christian era. Support for this hypothesis has always been the presence of domesticated sorghum finds in Arabia and the Indian subcontinent dating from the 2nd millennium BC, although much of this has been dismissed as wrongly dated or identified (e.g. Rowley Conwy 1999; Wigboldus 1990; 1996). A recent re-examination of the evidence for early sorghum in India however, argues that there is still good evidence that it was present in India in the early 2nd millennium BC (Fuller 2003). The 'Haaland Hypothesis' suggests an early date for domestication but outside Africa in for example, South Arabia (Haaland 1995; 1999). The objections to this argument stem from the lack of reliable finds of sorghum at early dates from Arabia. Finally the 'Late Hypothesis' argued by Wigboldus (1990) and Rowley-Conwy *et al.* (1997) argues for a late domestication in the Nile Valley. Evidence for this argument is supported by finds from Qasr Ibrim where the advanced races of sorghum (*durra*) are not present until the 10th century, with some intermediate races present in the 5th -7th century AD (Rowley-Conwy *et al.* 1999; Rowley Conwy 1991). Their argument is supported by DNA evidence which suggest domestication occurred somewhere in the region of the Nile Valley (Rowley-Conwy *et al.* 1999).

The sorghum finds from the Fazzān then add important new evidence to the debate, suggesting that domestication must have occurred significantly earlier than the Qasr Ibrim dates indicate. Furthermore the race apparently represented at Tinda is not that represented at Qasr Ibrim (*caudatum* rather than *durra*) raising the possibility that it derives from an independent centre of origin. Cultivated sorghum may also have been present at Napatan (800-400 BC) Kawa in Sudanese Nubia (Fuller 2004a) although there are some problems with the dating of these examples (Fuller *pers. comm.*). Clearly there is as yet insufficient evidence to satisfactorily plot the early history and subsequent spread of cultivated sorghum, however the Tinda material would suggest that more finds of early sorghum are likely as more archaeobotanical research occurs, and that more than one centre of domestication is possible. Further-more, it seems likely that sorghum was introduced into the Fazzān from areas to the south of the Sahara rather than from Qasr Ibrim and the Egyptian oases, although as yet it is not possible to trace its history further.

The evidence for cotton appears to be much clearer (see fig. 7. 4 for find spots of cotton seeds). As discussed above, cotton is first recorded in Africa in Nubia from Meroitic period contexts. New dates from Qasr Ibrim indicate its presence there during the 1st century AD (Alan Clapham, *pers. comm.*). It then appears to have spread westward via the oases to the Fazzān in the later Roman period, possibly fairly rapidly. In the early Islamic period there is a clear distribution on sites at the northern and southern ends of the western Trans-Saharan trade routes, with large deposits of cotton seeds at Volubilis in Morocco in the 9th century AD (Fuller, Pelling and De Varailles *forth.*) and at Dia in the Middle Niger Delta, Mali in Horizon 4 deposits (AD 1000-1600), and elsewhere in Mali by the 11th century AD. Given the large numbers of seeds present at Volubilis and Dia, as well as finds on established trading settlements it would appear that cotton was being traded as unprocessed or semi-processed bolls by the Islamic period. This is further supported by the recent identification of cotton seed from Islamic deposits at Tadmakka/Essouk, in the Malian Sahara, a major Trans-Saharan trade settlement in a region where it cannot have been cultivated (Murray, M.A., *forth*). The scale of production at Jarma is more suggestive of small scale domestic activity although it is possible that cotton cloth was being traded from the oasis sites, including Jarma, during the Late Roman period. Certainly the evidence of S- and Z-spun yarn at Nubian sites including the port of Berenike is usually interpreted as locally versus imported cloth (Wild and Wild 1998; Wild 1997). The evidence suggests that while the introduction of cotton into Western Africa may still be associated with Watson's 'Islamic Agricultural Revolution' (1983) it had reached the oases by the later Roman period.

7.5 Multivariate Statistical Analysis of the Data

It has been suggested on the basis of the crop species identified that agriculture in the Northern Fazzān has been influenced by both Mediterranean/Nilotic and sub-Saharan traditions. If the weed flora contains a significant number of non-indigenous species it might be expected that the floristic composition of the field weeds would reflect the flora of the regions from where new crops originated. Arable weed floras are by definition artificial in that they are the product of man's manipulation of nature. El-Hadidi (1992, 145) considered that 170 Egyptian weed species were the result of adaptation to agriculture during the Neolithic/Predynastic period (4500-3100 BC) increasing to 225-255 for the Pharonic period (3100-332BC). This increase in flora is related to an increase in the number and types of crops cultivated. Furthermore he suggests that the weed flora reflects both native flora (of the Saharo-Sindian, Sudano-Zambezian and Palaeotropical floras) which became incorporated into the arable weed repertoire over time, and species of Mediterranean, Irano-Turanian and cosmopolitan origin which were introduced with the cultivated plants from the southern Levant (el-Hadidi 1992, Table 1).

In an attempt to explore the relationship between the flora at Jarma and that of other sites across northern Africa, correspondence analysis (CA) was employed as a method of pattern searching (see figure 7.5 for a map of the geographical and temporal distribution of sites included in the analysis). As with the previous chapter the analysis was conducted using the programme PAST ver. 1.38 (Hammer, Harper and Ryan 2006). The pattern searching focuses on geographical and chronological relationships and makes use of the data compiled in the database. Presence absence data for taxa from each site were generated by the database. The data were manipulated and standardised in Excel before being pasted into PAST for the analysis. Presence/absence of taxa was used which should reduce the impact of differential preservation and context type as well as differences in density of remains. CA is regarded as well suited to pattern searching in terms of counts or presence/absence data (Greenacre 1984; Shennan 1997:308-52) and has been successfully employed to plot similar presence/absence data in order to trace the spread of farming in the Eastern Mediterranean (Colledge *et al.* 2004). The data file on which the analysis was performed consisted of a matrix with sites/phases (samples) in rows and taxa in columns.

7.5.1 Initial manipulation of the data

A range of manipulations to the data were applied in order to produce plots which most reliably reflected differences in the data. In the first instance the presence/absence of all field crops and weeds represented by desiccation or charring were selected by site and phase. Fruits and tree/shrub species were omitted. Only taxa identified to the level of genus, species or tribe were included. This resulted in the omission of small and large grasses or Leguminous weeds for example. In order to reduce the problems of variable levels of identification by different authors and different classifications the data were combined so that for example *Hordeum vulgare* and *Hordeum* cf. *vulgare* are combined as *Hordeum vulgare* or *Triticum durum*, *Triticum aestivum* or *Triticum* free-threshing are combined as *Triticum aestivum/durum*. The level of identification of small grasses is particularly problematic, particularly where identification is to type or groups of species. Species or genuses were therefore combined to reduce the variation caused by differential classification so that for example *Setaria* sp., *Brachiaria* sp. and *Setaria/Brachiaria* sp. were combined as one group.

7.5.2 Plot 1 All Sites/Phases and All Taxa

The full dataset consisting of all phases and all taxa, field crops (including oil and grain but not fruit or vegetable crops) and weeds, consisted of 97 phases and 326 taxa. The dataset was further reduced by omitting rare taxa (in fewer than 5% of phases) and phases with fewer than 5 identifications. The resulting data matrix consisted of 84 sites/phases and 87 taxa. The plot (fig. 7.6) shows a separation of the Sahel sites and the pastoral Neolithic sites from the rest by the 1st axis and a separation of the Sahel from the pastoral Neolithic sites on the second axis (see tables 7.1 to 7.6 for site locations and periods represented). The medieval site of Soba plotted with the Neolithic sites rather than the agricultural Sahel sites. By reducing the taxa further by omitting taxa present in fewer than 10 sites/phases or sites/phases with fewer than 10 taxa, a similar pattern was still observed, although the number of sites and taxa was reduced dramatically. The 5% and 5 taxa cut off was therefore adopted for all future plots, reducing the effect of rare taxa yet maintaining sufficient sites and taxa for useful pattern searching.

7.5.3 Agricultural sites only, rare taxa and small samples removed

It was clear that the pastoral sites plotted away from the agricultural sites and as they reflect different climatic conditions as well as food procurement activities they were omitted from further analysis. Figure 7.7 shows desiccated and charred crops and herbaceous weeds from all agricultural period sites. The Sahel sites/phases including the Soba phases clearly plot away from the Fazzān, Egyptian Nile Valley and Mediterranean sites. Qasr Ibrim and Berenike both in southern Egypt also plot away from the mass of Egyptian sites, with the other Nubian sites (Nauri and Kawa) being pulled in the same direction. Qasr Ibrim and Berenike produced remarkable assemblages with a very high density of desiccated crop remains displaying both Nilotic and Sahelian characteristics (both produced sorghum, cotton and the near eastern cereals for example). It is unsurprising that these sites plot away from the mass of Mediterranean and Egyptian sites. Clearly the Fazzān and the Egyptian oasis sites are more similar to the Egyptian Nile Valley and the Mediterranean sites than to the Nubian or Sahelian sites. In the case of the Sahel sites, the earlier phases (Kursakata) plot further away from the main data cloud than the Iron Age and Medieval sites/phases with the exception of Birimi Late Stone Age. This is likely to reflect the gradual adoption or arrival of Mediterranean/Near eastern crops in the Sahel/Inner Niger Delta region as trans-Saharan trade developed, particularly during the Islamic or Medieval period. Generally however, the geographical separation of all the sites on this plot is clearly far stronger than any chronological separation.

Figure 7.8 shows the Egyptian Nile valley, Mediterranean, Egyptian Oasis and Fazzān sites, omitting sites with fewer than 5 taxa and taxa present in fewer than 5% of sites. All Nubian sites including Qasr Ibrim have been removed, as has Berenike. The data matrix was reduced to 39 sites and 54 taxa. In this plot there was clear separation along axis 1. The Fazzān sites, the Egyptian Oases and Medieval Carthage were separated from the remaining sites by the 2nd axis, with Jarma and Tinda B plotting much further to the left than Zinkekra and the Oasis sites. There was also some separation along axis 2, with the Mediterranean sites, except Medieval Carthage and the ULVS sites plotting above axis one and the majority of the Egyptian sites (except Tell Ibrahim Awad (AwadLPre and AwadEDyn) and Minshat Abu Omar (MinsEDyn)) plotting below axis 1 with the oasis sites, Zinkekra Medieval Carthage and the ULVS sites. The Algerian Setif phases plotted slightly away from the bulk of the Mediterranean sites/phases along axis 2. On axis 2 and 3 (fig. 7.8) Setif plotted well away from the other sites in the top right corner. The test was therefore run once more with Setif removed (fig. 7.9). A similar distribution was produced to figure 7.8 with Jarma, Tinda, the Egyptian Oasis sites, Zinkekra and Medieval Carthage plotting to the left of axis 2 and the other sites to the right. Jarma plotted to the far left away from the oasis sites/Zinkekra. Most of the Egyptian sites, the oases sites, ULVS and Zinkekra were separated from the Moroccan, Tunisian and the remaining Egyptian and Libyan sites by axis 1.

Finally the analysis was run with weed seeds only, this time including Setif. The most recent Jarma phase (phase 1-2) is also omitted to reduce the effect of post-medieval New World species. Taxa present in fewer than 5% of sites were removed, thus resulting in the loss of the oasis sites, the ULVS sites, some Moroccan sites (SehirEI, SeghirLI and SijiIsla) and some Egyptian sites (HibePtol, LahunMidK and Omar PDyn). The resulting plot is shown in figure 7.10. Again The Fazzān sites plot away from the rest to the left of Axis 2, although this time Zinkekra plots much more closely to the remaining Fazzān sites. The Greco-Libyan site of Eusperides (EuesGrec) also plots to the left of Axis 2. Setif appears to plot away from the Mediterranean/Egyptian sites.

7.5.4 Explaining the Patterns Observed Using Charred and Desiccated Absence/Presence Data

In all the manipulations conducted above the Jarma and Tinda phases plot away from the Mediterranean/Egyptian sites suggesting that there is a real difference. The exclusion of the crop plants indicates that this difference is reflected in the weed flora as well as the crop species, although the difference between Jarma/Tinda and Zinkekra is reflected more strongly when the crop plants are included. The apparent close association between Zinkekra and the oasis sites is particularly interesting, although it is unfortunate that weed seeds were rare in the oasis phases. As analysis on the samples from the oasis sites is generally in an early stage it is hoped that these patterns can be explored more fully in the future once analysis is complete. It is clear that the greatest difference is, unsurprisingly, between those sites in the northern Sahara and Mediterranean coast and those to the south (the Sahel sites) while the northern Saharan sites (the Fazzān sites) are more Mediterranean/Egyptian (or Near Eastern) in character than the Sahel sites. This would suggest that despite the adoption of Sahel crops the weed flora in the Fazzān continues to be dominated by more temperate zone weeds than the weeds of the Sahelian, summer rainfall belt.

It was suspected that the difference between the Jarma and Tinda phases and the other Maghreb/Egyptian sites including Zinkekra was due to the adoption of summer crops at Jarma and Tinda and changes in associated weed flora. To test this hypothesis the plot of Fazzān /Maghreb/Egyptian sites with crop and species (fig. 7.8) was recreated plotting taxa rather than sites (figs 7.11 and 7.12). Taxa names were replaced first by broad habitat codes (arable fields, waste places, steppe/desert, wet ground or irrigation channels, catholic) and secondly by seasonal status (winter/summer crop and winter/summer weed). While the patterns are not particularly clear figure 7.11 shows a cluster of summer crops and desert/steppe species (code 4) to the left of axis 2, suggesting these taxa were pulling the Jarma and Tinda phases in this direction. The concentration of winter crops was far greater to the right of the second axis. Figure 7.12 shows the same plot using seasonality. Again there is a distribution of summer crops and weeds to the left of axis 2 suggesting these were affecting the position of the Jarma and Tinda phases. While the habitat data is very broad and the number of taxa limited it does appear to be the fact that the summer crop and weed seeds are affecting the plots. While this is to a certain extent obvious it is useful to demonstrate it statistically. It is particularly interesting to note that the summer crops and weeds appear to cause some separation of Zinkekra from Jarma and Tinda, although the separation is reduced once the crop plants are removed.

7.5.5 Charred Samples Only

The limitation and problems associated with the data and the analysis are discussed below (section 7.5.7). The most obvious problem however is that of differential representation of charred and desiccated remains. The issue of different levels of identification and sampling methodology is also significant. At some sites, such as Lahun (Germer 1998) or El Omari (Barakat 1990) stored, presumably hand picked material from old excavations was re-examined with limited information about sampling. At several of the sites with large quantities of desiccated material the volume of remains is so vast that identifications have largely been limited to arable crops or large items. In the case of El-Hibeh, for example, only material collected in the 4mm sieve was examined, although small seeds adhering to the larger material was also identified, thus providing a good range of taxa (Wetterstrom 1994). While the more common weed seeds have often been identified along with the crop plants or larger items there are clearly problems of statistical reliability. The use of presence/absence data and omission of rare taxa reduces the problems to a certain extent, although the problem of differential preservation is still significant. As has been mentioned in previous chapters desiccation favours certain plant parts over others. While it is possible that those species will still be represented by either preservation mode (e.g. by charred seeds or desiccated chaff) it is important to run the tests with only one type of preservation. As the majority of the incompletely identified datasets were from sites with desiccated remains (these being the sites which produced the most abundant assemblages), by using charred data only the problem of different sampling/identification methods is reduced as well as that of differential preservation.

The remaining analyses use charred field crops and weed species data only. Taxa present in fewer than 5% of sites/phases and sites/phases with fewer than 5 taxa were omitted. Figure 7.13 shows all sites/phases with charred material omitting phases with fewer than 5 taxa and taxa present in fewer than 5% phases. The matrix consisted of 46 phases and 60 taxa. As with the previous plots there is a clear separation of Mediterranean/Egyptian and Fazzān sites from the Sahel sites along the 1st Axis. Furthermore the Fazzān phases, along with the Sudanese phases and the Inner Niger Delta and Burkina Faso phases were separated from the rest by the second axis, with the Kursakata phases plotting separately in the bottom right quadrant. The Soba phases plotted more closely to the Fazzān phases than the Sahel phase, suggesting that preservation may have made some difference to the placing of these phases. The analysis was then run without any of the Sahel sites (a similar plot to fig. 7.13 was achieved by omitting Kursakata phases).

Figure 7.14 shows the plot of charred Fazzān, Mediterranean, Egyptian and Nubian phases (35 phases). Again there was a strong separation of the Fazzān phases from the rest by the second axis. There was also a separation of Soba phases from the rest in the top left quadrant. (The removal of the Setif Islamic phases and/or the removal of the Soba phases did not alter the distribution of the remaining samples significantly). Figure 7.15 shows the plot of the sample sites/phases using weed taxa only (26 phases, 31 taxa). A very similar plot to figure 7.10 (desiccated and charred, weed taxa only) was produced, the plot being flipped and the desiccated samples missing, but with the position of the charred sites almost identical. This suggests that while the position of the sites with desiccated remains may be affected by preservation they do not in themselves affect the position of the charred data. As in the previous plots, the Jarma and Tinda phases plot away from the other Maghreb and Egyptian phases. The Greco-Libyan site of Eusperides plots to the left of axis 2 with the Fazzān phases although not as far to the left. The Setif phases plot away from the other Maghreb/Egyptian phases in the bottom right quadrant.

7.5.6 Explaining the Patterns Observed in the Charred Material

The CA plots using charred data only demonstrate that the patterns are essentially the same whether or not desiccated assemblages are included and regardless of sampling technique or levels of identification. This argues in favour of using absence/presence data for pattern searching on a broad level, the exclusion of rare taxa and absolute numbers presumably reducing errors introduced by uneven sampling and preservation. For more detailed regional pattern searching this is likely to be different and as such pattern searching would need to start from first principles exploring biases in the data before any conclusions are drawn. Both sets of plots indicate that the Fazzān phases have a distinct character from the other Maghreb and the Egyptian sites/phases. The positioning of the Greco-Libyan site of Eusperides may indicate similarities between this and the Fazzān sites. Most noticeable is that the separation of the Fazzān sites from the others is unaffected by chronological period. The differences therefore again appear to be geographical rather than chronological.

Figures 7.16 and 7.17 show the position of taxa (field crops and weed seeds) using habitat and season codes, while figures 7.18 and 7.19 show the plots of taxa for weeds only, again using habitat group and season codes. In both sets of plots the patterns are similar to those generated by using both charred and desiccated remains. The concentration of desert/steppe species and in particular summer weeds and crops appear to pull the Fazzān sites/phases away from the other sites. The fact that the plots using weed taxa only agrees with that using weeds and crops suggests that it is not the presence of summer crops alone, but those weed seeds presumably associated with them.

7.5.7 Limitations of the Data

There are a number of limitations with the data, not least the huge temporal and spatial gaps, which need to be considered before any final hypotheses are put forward. The unevenness of the data must be considered in any attempt to study pan-regional data or reconstruct agricultural diffusion (e.g. Zohary and Hopf 2000: 247). As mentioned above there is considerable variation in the sampling and recovery methods and level of identification employed by different specialists, as well as different levels of experience and quality of reference material. Archaeobotanical material from Egyptian sites in particular has been recovered over a period of more than a century and includes material recovered before the advent of flotation. Some of the material has been sitting in museum stores for several decades and will have suffered decay. There will inevitably have been some variation in the data as a result these disparities. Outside of Egypt excavation and sampling techniques have been more systematic given the relatively recent timeframe over which archaeobotanical sampling has been employed in the continent. Even so the archaeology itself is very different, with classical urban centres on the Mediterranean coast, inland Romanised farmsteads, mud brick desert settlements and large, often largely featureless sub-Saharan settlement mounds. The archaeological methods applied to excavation are consequently varied which will have had an inevitable impact on recovery of archaeobotanical material.

In additional to methodological disparities the archaeobotanical material itself is very varied, and taphonomic processes must affect the data differently, particularly between different regions. The differential survival of desiccated and charred remains has been noted. Desiccation tends to favour a greater range of plant parts while grass caryopses tend to survive poorly. Charring occur after contact with fire so tends to be restricted to material which is more likely to be burnt, for example on household fires or (more rarely) in more catastrophic burning events, for example the burning of storerooms. The density of remains preserved by desiccation tends to be much greater than for charred remains. The taphonomic processes applied to different crop types, particularly the Near Eastern cereal crops (wheat and barley) versus the sub-Saharan cereals (pearl millet and sorghum) are quite different due to harvesting methods (see chapter 6). The range of weed seeds harvested with the crops and therefore likely to enter the archaeological assemblage will be greatly affected by harvesting method and subsequent processing. It would be expected therefore that a far greater diversity of weed flora would be recovered from the northern wheat and barley growing areas than the southern pearl millet/sorghum areas.

These problems have similarly been addressed by Colledge *et al.* (2004) in a study of the spread of farming in Mediterranean Europe, and by Lange (1990) from Iron Age and Roman period sites in De Horden, the Netherlands. Lange found that while the taphonomic processes are likely to have affected the original composition of the assemblages he found that this was not responsible for the more important trends visible in the data (1990: 135). Colledge *et al.* (2004: 46) similarly found that sites clustered in accordance with their geographic location regardless of differential treatment, specialist experience or sampling methods, suggesting that the most significant trends were not affected. Similarly in the current analysis clear geographical trends are visible even when using both desiccated and charred data, suggesting this is the most significant variable affecting the data. It is likely that limiting the analysis to the level of absence/presence and by omitting rare taxa and small sites/phases the impact of variable taphonomic processes and recovery/ analytical techniques will be minimised. The analysis is intended to explore broad trends in the data only and is not intended to examine differential processing techniques, scale of production or economic status of sites; therefore it is felt that it is appropriate as a first stage of analysis in observing the diffusion of crops and associated weeds on a pan-regional basis.

Problems which are more difficult to overcome involve distinguishing natural and arable floras and the lack of detailed ecological information for many of the taxa. It is generally difficult to distinguish between natural local vegetation and that associated with cultivation, therefore making it difficult to distinguish patterns which are purely geographical and those which reflect true patterns in the weed flora resulting from the diffusion of crops and associated weeds. Similarly there is no allowance for identifying herbaceous species which have entered the site as arable weeds from those which have been brought in as animal fodder or through dung. These are possibly the most difficult issues to overcome and in the absence of good pollen records for much of the area it is simply not possible to rule out natural vegetation being more significant than arable weeds in the vegetation signature of the different sites or regions. In the Fazzān sites for example the difference between Zinkekra and Jarma may be in part explained by different location. Zinkekra is a promontory fort on the escarpment to the south of the wadi floor and the prevailing winds blow from south to north. The amount of wind blown vegetation likely to have entered the site is therefore limited compared to Jarma. However, for both sites non-arable weeds may have been blown onto the threshing floor and entered deposits prior to them being brought into the site. It will never be easy to reduce the impact of natural vegetation but it can only be assumed that the bulk of the weeds persistently associated with crop species are present as weeds and this should become clearer as more data are available and more in depth examination of samples rather than sites is conducted.

7.6 Conclusions and Interpretation of the Data: the Evolution of an Oasis Flora

Taking into account the limitations discussed above there are some final hypotheses which can be made concerning the evolution of the crop and weed flora at the Jarma and Tinda sites using both the CA ordination technique and the timing and occurrences of key crop species across the Pan-Saharan/North African region. Of interest are the field crops and their associated weeds, but also the more significant fruit crops. The rarer fruit crops (olives, pomegranate etc) come under the category of 'luxury foods' and therefore need to be treated differently. Luxury foods are discussed in the following chapter with other evidence for changes in food culture.

Correspondence analysis was used as a means of pattern searching the pan-regional data to investigate the impact of introduced crops on the floristic composition of the Fazzān sites and in particular the weed flora. It was hoped that patterns would emerge that reflect the broad trends seen in the crop data. While it is difficult to make conclusive statements about the patterns, it is clear that the Fazzān data is sufficiently distinct from the other Maghreb sites and the Egyptian sites, including the oases, that the differences are visible in the ordination plots. On the basis of the plots it is proposed that the initial agricultural and weed flora produced a signature similar to the Egyptian Oasis sites, with the northern, temperate flora having a greater impact than southern or desert floras. While the temperate, northern flora continued to be present over time a more localised flora appears to have evolved. It is suggested that the presence of the summer crops and associated weed seeds created a distinct flora which is different to that seen at Zinkekra or the Egyptian oases. While the presence of desert grasses may simply reflect the natural vegetation it is significant that they include grasses not recorded in the flora of the region today, notably *Brachiaria ramosa/deflexa* and *Brachiaria/Setaria* type grasses. *Brachiaria ramosa* and *B. deflexa,* while both edible grasses, also occur as weeds of cultivated crops in much of sub-Saharan Africa (Burkill 1994, 191, 194). While this could suggest it was present as a contaminant of imported pearl millet grain the ubiquity of pearl millet does suggest it to be cultivated locally. It is likely therefore that *Brachiaria ramosa/deflexa,* as well as other summer weeds were introduced with seed grain from the Sahel regions and persisted until recently as a weed.

The crop repertoire in the Fazzān has been shown to be dominated by important Near Eastern cereals but also contains Sahelian crops at relatively early dates. Agriculture in the region was established by the early part of the 1st millennium BC based on the Near Eastern staples of emmer wheat and barley, with some bread type wheat, supported by perennial fruits (grapes, figs and dates) and aromatic herbs (Van der Veen 1992a). The inclusions of the perennial fruits would suggest that either agriculture had already been established for some time in the region or that it was introduced as a package by experienced agriculturalists. Correspondence analysis supports the hypothesis that agriculture was introduced from the Mediterranean or more probably the Egyptian Nile Valley/Oases. Initial agriculture must have been based on well fed irrigation or water must still have been accessible at the base of the escarpment. It is now believed, however, that surface water at the base of the escarpment was absent or rare by 3,100 ±125 BP(Drake et al 2004), coinciding with the start of occupation at Zinkekra. It is significant that agriculture is first recorded at the time when surface water appears to be becoming particularly scarce. It is possible that population and agricultural pressure as a result of the increasing humidity of the Sahara was resulting in the colonisation of new areas by oasis agriculturalists. However, until the identification and sampling of further contemporary and earlier sites produces archaeobotanical and supportive cultural artefacts or DNA this remains speculative. Certainly the pan-regional analysis of crop and weed floras does not disprove this theory of migrating settlers bringing a fully formed agricultural package to the area by the early 1st millennium BC.

The precise timing of the adoption of the *foggara* and the move to wadi floor settlements like Jarma is still unclear. It does appear however, that the two are related (Wilson and Mattingly 2003). In some areas of the Wādī al-Ajāl occupation of escarpment sites continued, for example at Tinda B. The current study demonstrates that at both Jarma and Tinda B the end of the 1st millennium BC is associated with the adoption of the Sahelian crops, pearl millet and sorghum, as well as a possible greater reliance on bread type wheat. Future excavation of other sites in the region will reveal if this is a wide-spread pattern. The subsequent Classic Garamantian period is associated with the continued expansion of the crop repertoire as well as the possible importation of 'luxury' food items. Significant among the later crops to be adopted is cotton, present from at least the 3rd or 4th century AD, and durum wheat from 100 to 400AD. The exploration of the pan-regional data highlights some important data to suggest the Fazzān was involved in contact with peoples to the south and south east of the Sahara as well as to the north and east, essentially supporting the notion of trade across the Sahara long before the Islamic period of long distance trans-Saharan trade.

The archaeobotanical data therefore support the notion that the farmers within the Fazzān were receiving new crops and ideas from regions around the Sahara, not simply from the Romanised north or Egypt. While it is difficult to assess the significance of the various crops, particularly given the different harvest techniques and uses of crops, which result in differential preservation (see chapter 6), it is suggested given the ubiquity of pearl millet in particular that the sub-Saharan crops formed an important part of the Garamantian crop repertoire which has continued until the current day. The weed flora appears to have evolved over time to include summer flowering species which are likely to have been introduced with the summer crops. The correspondence analysis suggests that as more data become available it may be possible to trace the route of introduction of crops and weeds and their impact on the flora in more detail. It is important to stress that archaeobotany in Africa as a whole is still a relatively new subject and there are considerable gaps in the data both temporally and spatially. The database so far constructed is an important starting point for exploring the pan regional data and as more data become available the potential for more conclusive pattern searching will be increased.

Chapter 8

FOOD AS A CULTURAL ARTEFACT: THE ARCHAEOLOGICAL AND ARTEFACTUAL EVIDENCE

8.1 Introduction

The previous chapters have attempted to trace the timing and possible pathways of crop introductions and consequently changing crop husbandry traditions over time. The way in which new food types are absorbed into a society may tell us something about that society itself. Food, and more specifically how we prepare and consume it, both in terms of daily staples and ritual consumption, is closely associated with cultural and social identity (e.g. Palmer 2002; Lyons and D'Andrea 2003; Edwards 1996b). As such the artefactual and feature evidence which relates to food production and consumption may provide clues concerning both social structure and cultural identity which may add an intriguing dimension to the study of past populations in the Fazzān, an issue which is particularly pertinent to the study of the Garamantes. Of particular interest in terms of crop introductions is how they arrived: did they arrive with new populations and new cultures or were they absorbed into existing systems. If they arrived with new populations other evidence for food culture might be expected, such as changes in utilitarian pottery types or cooking/baking technology. This chapter presents the archaeological and artefactual evidence recovered from both the recent excavations at Jarma and survey in the Wādī al-Ajāl by both the Fazzān Project (Mattingly 2003; 2007) and previous projects (Daniels 1968; 1970b; 1971b; 1973; 1977; 1989). A discussion of the potential cultural and social implications for this data and how they fit in with similar data from the wider region is presented in the concluding chapter.

As discussed in the introductory chapter, artefacts associated with food and consumption were recovered from both the excavation at Jarma and from field survey as part of the Fazzān Project. While final reports were not available at the time of writing for all artefactual data, the hand made pottery (Dore, Leone and Hawthorn 2007; Leone *forth*), stone tools (Parton 2007; *forth*) and animal bone (Britton and Grant *forth*) reports were available. This chapter presents the data from these reports where relevant to the current study, along with the feature evidence from the excavations (from Thomas *forth*). In addition data from previously excavated burials and the surveys by the Fazzān Project and Charles Daniels are presented where relevant (Mattingly 2003; forth b.; forth c.). The association of artefacts connected with food and drink with mortuary structures or structures possibly associated with religious buildings, is regarded as particularly significant and while must not be taken as purely representative of food consumption in life must surely reflect the importance of certain foods or food technologies in society as a whole.

8.2 The Pottery

The pottery recovered from both the excavations at Jarma and previous excavations and survey in the Wādī al-Ajāl fall into four principal groups: the fineware, amphorae, coarseware and handmade ware. Pottery reports on the Fazzān Project survey and Daniels archive is published in Dore, Leone and Hawthorn (2007). The pottery from the excavations at Jarma will be published in Leone (*forth*). The imported pottery (fineware, amphorae and wheel made coarseware), mostly derives from the Mediterranean, particularly the North African coastal regions, and generally dates to the Classic Garamantian period (1st to 5th century AD), with the greatest occurrence being late 1st and 2nd century AD. The earliest imported wheel made pottery dates from the last three centuries of the first millennium BC. 'Punic' type amphorae and large courseware bowls dominate the early assemblages, a significant proportion of both coming from Tinda B. Also identified were a single Hellenistic white-ground lagynos, dated to c.150-50BC, and small 'Black Gloss' bowls with parallels from the Bab Bun Gascur necropolis in Tripoli. The greatest proportion of imported finewares is of 1st to 6th century AD date, greatly biased by Italian Sigillata from the cemetery site of Sāniat bin Huwaydī. South Gaulish and Eastern *sigillata* and African and Tripolitanian slipware form the rest of the fineware assemblage (Edwards *et al* 1999; Dore, Leone and Hawthorn 2007). Late Roman finewares are under-represented and it is believed that there was a decrease in supply in the later Garamantian period (Dore, Leone and Hawthorne 2007, 308). Occasional later imported Islamic period vessels and fragments are recorded but are as yet unpublished and the small number suggests minimal trade in fine wares in the post-Garamantian period.

The Amphorae derives from a fairly restricted range, most commonly of Tripolitanian origin (Panella 1973) ranging from the late 1st to as late as the 4th century AD (Dore, Leone and Hawthorne, 2007; Edwards *et al* 1999). A more limited range of central

Tunisian amphorae is 2nd to 3rd century in date. Late Roman types were limited suggesting a decrease in their import. Both the Tripolitanian and Tunisian forms are generally assumed, but not proven, to have contained olive oil (Panella 1973; Carandini and Panella 1981; Peacock and Williams 1986, 166-70; 87; Edwards *et al* 1999). The small size of the Tripolitanian forms however raises the possibility of a commodity of higher unit value, such as wine (Dore, Leone and Hawthorne 2007). An earlier form found at Jarma dates from the 1st century BC or earlier, is a rim of a Greco-Roman or Italian Dressel 1A type, both of which were used for wine (Edwards *et al* 1999). This would indicate that in the late part of the 1st millennium BC wine was being imported into the region, although the scale of such imports is impossible to assess on current evidence. Olive oil appears to have been a significant import during the 1st to 4th centuries AD, possibly associated with oil lamps given the occurrence of amphorae and oil lamps in graves (see below).

The range of courseware was diverse but included few well recognised types apart from various casserole types (full catalogue given in Dore, Leone and Hawthorn 2007). Late 'Punic' type bowls, dominated by an assemblage from Tinda B, are large heavy, fairly shallow bowls with a gently curving profile. These have parallels from Sabratha and Carthage (Dore and Keay 1989; Dore, Leone and Hawthorne 2007), dating from the last three centuries BC. A range of large bowls or basins, small bowls and casseroles continue into the Roman period, again generally having parallels from the coastal regions and are assumed or, in some cases, demonstrated to derive from northern potteries, particularly Sabratha, Carthage and Leptiminus with some from the Tripolitania pre-desert and central Tunisia (Dore, Leone and Hawthorne 2007). These forms fall in date between the 1st and 5th century AD, with the greatest concentration of 1st to 3rd century date. The wheel made coarseware also includes a range of jars, flagons, mugs, lids and pedestal vases, similarly believed to derive from northern potteries and are Roman date, with some forms being late Roman (4th to 6th century).

The handmade ware covers the early Holocene to the present day. A range of types are characterised by material recovered from Zinkekrā spanning the 1st millennium BC and are classes as 'Zinkenkra ware. These include one form (type 305) which is recovered from other sites including inter-dune areas of the Ubari sand sea and are consequently thought to be as early as middle pastoral in date, suggesting both longevity of some types and an association between earlier pastoral groups and the Garamantes (Dore, Leone and Hawthorne 2007). Three basic forms of coarseware are identified which exist from the early 1st millennium BC until late Antiquity: large bowl/cauldron/jars, a globular jar including long-necked forms, and a flat 'frying pan' or *doka*. Some forms of jars and bowls continue into the Islamic and early Modern period. A change in pottery fabric and evolution of forms occurred during the period 1st century BC – 1st century AD. There was a shift from dark burnished ware known as 'Zinkekrā ware' to 'Berber red' and 'Berber Black' wares in the 1st century BC to 1st century AD (Edwards *et al.* 1999). The most significant evolution of forms was an increase in the use of small bowls and the evolution of globular jars into everted-rim jars (Edwards *et al.* 1999; Leone *forth*). The everted-rim jars have parallels elsewhere including southern Algeria, were similar forms are often found in funerary contexts from the Bronze Age onwards in association with prestige goods (cf. Balout 1958, 162; Camps 1961, figs 93, 94, 98, 165 ,166; Edwards *et al.* 1999, 121). Such jars are likely to have contained liquid or semi-liquid foods, and their association in funerary contexts with fine wares and amphorae raises the possibility of ritual drinking as part of funerary rites. Long necked globular jars are prominent in Meroitic and post-Meroitic assemblages in the Middle Nile Basin of Nubia, particularly in grave assemblages, and have been associated with beer due to their similarity with beer-jars in use in Sudan in the early 20th century (Crowfoot 1925). A decline in liquid containers in Nubia is visible in the assemblages of the Christian period (Adams 1986). It has been suggested that beer consumption (possibly of sorghum beer) may have had a long history in the Middle Nile Basin and may have been particularly significant in mortuary rites, possibly being consumed both in mortuary banquets, but also during the construction of the often substantial tumulus mounds covering burials (Edwards 1996b, 74). Globular jars then are a re-current feature in African archaeological assemblages, as they are in current pottery repertoires in much of the continent, most usually associated with beer (eg. Arthur 2003). The possibility of drinking rites associated with Garamantian burial may mirror similar patterns in a wider area of Africa including southern Algeria and Nubia.

The *doka* types appear in contents dateable to the 1st century BC to 1st century AD at Saniāt Jibrīl, and Zinkekrā. They then continue to be common in 2nd to 4th century and early medieval deposits and thereafter apparently absent. *Dokas* are wide, shallow dishes with a slight rim or lip with parallels across much of northern Africa. Ceramic *doka* occur in Sudan during the Christian period from about 600AD (Adams 1986, 158; Shinnie and Shinnie 1978, 107) and are thereafter common until they were widely replaced by metal pans or sheets in the 19th century (Dirar 1993, 173). They have been associated with bread making on the basis of the absence of bread making ovens (Edwards 1996, 75). The Fazzān examples have impressions of straw matting on the base, while one example is decorated with red dots and lines on a white surface. It has been suggested therefore that the decorated example is associated with the presentation of food, and the lack of signs of contact with fire suggests they were placed in the vicinity of the heat source rather than directly on the fire (Dore, Leone and Hawthorne 2007). Similar ceramic griddles have been associated with mid-first millennium BC sites in highland Ethiopia (Dombrowski 1971, 123, 130). At Aksum they are uncommon until the later Aksumite period in the mid 1st millennium AD (Phillips 2000, 391). The Ethiopian and Sudanese *doka* must be considered part of a similar African tradition of pancake bread manufacture which may also be seen in Garamantian and early medieval period Fazzān.

8.3 Evidence for Bread Production

Structural evidence for the cooking or preparation of food was generally limited at the site suggesting kitchen or cooking areas may have been fairly informal. Evidence for fires was largely derived from shallow scoops filled with ash suggesting cooking may have been conducted over a simple fire or a simple three-stone hearth type feature. Such scoops or fire patches were noted throughout the period of occupation at the site and may have derived from simple fires or from three stone hearths as used across the region today. The evidence for *dokas*, associated with flat, pancake type bread, has been discussed above and these and various of the deep bowls or casseroles are likely to have been placed on or near fires which may leave little or no trace in the archaeological record.

In addition to the *doka*, more substantial structure evidence for bread production comes from four examples or *tanur* (or *tanoor*, *tabūn* in Jordan) bread ovens recovered at Jarma, all in the upper phases (4 to 1) only (Thomas *forth.*). Two phase 3 examples were identified: feature 0337 in the southern part of external area Ex. 3.1, located close to fireplace 0432, and a second example in Rm. 3.7. In phase 2 a *tanur*

(0167) was again excavated in an apparently external area in the southern part of the excavated area. Finally in phase 1, a possible *tanur* (feature 0142) was located in the southern part of courtyard area Ex. 1.5. The phase 3 t*anur* feature 0337 was associated with a small pit from which sample 03PF/105 was taken. This sample has produced evidence for the use of cereal chaff (wheat and barley) and animal dung (particularly sheep/goat) for fuel (chapter 6). The use of dung ash for heating *tabūn* bread ovens has been noted in Jordan (Palmer 2002, 179) and for *tanur* ovens elsewhere (Samuel 1999; Lyons and D'Andrea 2003). Palmer mentions that in Jordan it is only those who have access to animal dung (cattle, sheep or goat) who are able to maintain the bread ovens (2002, 179). In addition a large stone and mud-brick over or fire installation (feature 0489) was identified in phase 4 in a courtyard or open area to the south of the central, large rectangular room or building (Rm. 4.1).

It is possible that the disappearance of the *doka* is related to the introduction of the domed ceramic *tanur* (or *tanoor*, *tabūn* in Jordan) bread oven. *Tanur* or *tabun* type bread ovens are part of a Near Eastern bread making tradition, found in Mesopotamia by 3100 BC and Bronze Age Jordan (1500 BC) (McQuitty 1984, 261; Samuel 2000, 566). Similar cylindrical ovens, constructed with a ceramic cylindrical liner and mud brick and plaster casing, were introduced in to Egypt during the New Kingdom (1580 – 1085BC), and are the only structural features convincingly identified as bread ovens for the period (Samuel 1989; 1999, 131; 2000). *Tanur* have been recorded in Mediterranean North Africa and the Moroccan Atlas, eastern Sudan and Zanzibar (Balfet 1975; Bruneton 1975; Pomeranz and Shellenberger 1971; quoted in Lyons and D'Andrea 2003). They are used to bake flat bread made of wheat or barley throughout Southwest Asia, sorghum in southern Arabia and sorghum and millet in Yemen (Bornstein-Johanssen 1975 in Lyons and D'Andrea 2003). The late appearance of the *tanur* in the Fazzān may be due to preservation or lack of recognition, however if is it genuinely absent in earlier deposits this would suggest it was an Arab introduction. Other forms of bread making may have been widespread but have not left obvious traces in the archaeological record (ethnographic examples are discussed in the following chapter).

8.4 The Quern Stones and Mortars

Quern stones, rubbers, mortars and possible pounders were encountered throughout the excavated sequence of deposits at Jarma in some number (Parton *forth.*) and from survey or excavation elsewhere in the wadi, including Zinkekrā (Daniels unpublished archive; Mattingly 2003; Parton 2007) and mortuary features (Mattingly and Edwards 2003). A large proportion of the stone objects were recovered during the Jarma excavations came from the footings of a single wall (feature 3017) in excavation area G3, thought to be the foundations of a substantial phase 2 building (Thomas *forth.*).

A total of 464 stone objects were recovered from the excavations at Jarma, the full report of which is given in Parton (*forth*). Two types of quern stone were present at the site, saddle querns (including rubbers), of which 41 were recorded, and rotary hand querns of which 148 were identified (Parton *forth*). Rotary querns first appear in the Fazzān, both at Jarma (from phase 7) and elsewhere, in the 1st or 2nd century AD prior to which only saddle querns are reported (Parton, *forth.*; Mattingly 2003). Early rotary quern stones include examples of basaltic lava imported from the Roman province to the north, while locally produced stones of local sandstone occur thereafter in a range of local styles (Parton *forth.*; Mattingly 2003; figs. 8.1 and 8.2). In the excavated sequence the number of rotary hand querns increase from phase 5 thereafter outnumbering the saddle querns. The saddle querns are recorded throughout the excavated sequence, although nearly half come from phases 8 to 6 suggesting an apparent, although incomplete, replacement of saddle querns by rotary querns over time. There is no concrete evidence in terms of archaeobotanical remains to suggest a change in the scale of grain grinding in this area during phase 5 (the archaeobotanical samples in fact suggest cereal processing waste rather than grain product dominates these samples suggestive of fodder or fuel deposits, see chapter 6). Parton suggests therefore that the shift in numbers of querns is likely to simply indicate a transition to the more advanced rotary querns (Parton, *forth.*). In the later occupation phases at Jarma plaster rotary hand quern bases were found situated within (presumably domestic) rooms (Thomas *forth.;* Parton *forth.*), similar to those still used in houses by older residents in the region today (Abdul Rackman *pers. comm.*; Parton *forth.*). While the presence of stone objects is difficult to interpret given their potential for re-use as building material, the continuation of the saddle quern despite the presence of rotary querns is of interest. This could be an issue of scale or value or may be related to different culinary activities or the grinding of non-food material. Ethnographic evidence for quern stone use is presented in the following chapter.

A range of mortars and pestles were present throughout the occupation phases, of varying depth and quality, frequently re-used as structural stone. The mortars fall into two main groups of which the first consists of large, deep tapering mortar hole, the other consisting of shallow holes including multi-holed types. Mortars tend to be roughly made but regular in shape and show use for both grinding and pounding suggesting a range of uses which might include pounding grain crops, particularly millets, fruits or non-food material. Mortars are present in all phases from phase 7 to the top of the sequence, with a particularly high number (22) from the 'quern wall' in phase 2. Staining on the stone of some mortars at Jarma indicates their use for grinding non-food items such as ochre (Parton *forth.*). They may also have been used in the preparation of grains. Hulled grains (emmer wheat in this case, but also hulled millet type grains) require de-husking before they are ground for flour. While there is considerable debate in the literature surrounding the use of parching versus pounding (see Peña-Chocarro and Zapata 2003 for an overview), the feasibility of pounding in the removal of husks has been demonstrated experimentally by D. Samuel (1993), in her reconstruction of ancient Egyptian emmer processing. Dehusking of hulled wheats in Spain was conducted with mortars and pestles in the recent past (Peña-Chocarro and Zapata 1998) and in Turkey (Hillman 1984). The pounding of small hulled millet grains is widespread in African and India (e.g. Reddy, 1997). While no hulled food millets have been positively identified at Jarma it is possible that some of the wild grasses present were used for food.

The 'quern wall' (feature 3017), is interpreted as a substantial foundation wall in area G3 dated to phase 2 and which was apparently built entirely of quern stones, mostly in very good condition, come complete and some even apparently unused (Parton, *forth.*; Thomas *forth.*). Thomas suggests the construction of the wall may have been a collaborative project to which residents donated stone tools, or included stone tools scavenged from earlier buildings, the 'recycling' of the stone perhaps reflecting the poverty of the later Medieval/Islamic period (Thomas, *forth.*). Given the value of quern stones their donation to a communal building project may infer some symbolic significance such as the wealth of the donor, or greatness of sacrifice to the construction, particularly if it was for a mosque.

Quern stones were recorded in the funerary assemblages of some graves of Garamantian date in the Wadi, which further suggests a special significance. At the Garamantian period cemetery site of Sāniat bin Huwaydi, excavated by Daniels, flat leaf shaped rubbers or saddle querns were recorded until the early 1st century AD. From the 1st century to the 4th century graves include rotary querns, the earliest examples of which are of Basaltic Lava (Mattingly 2003c). Further examples of both rubbers or saddle querns and later rotary querns were recovered from the so called 'Royal Cemetery' of similar date (Mattingly and Edwards 2003, p. 207). In all instances the rubbers or quern stones form part of a burial assemblage which includes eating and drinking vessels, and which must relate to food offerings of some sort (see below for discussion of burial assemblages).

Quern stones then may have held quite specific social significance. How this relates to the evolving economy of Jarma is unclear. The use of quern or mortar type may be associated with cultural origins and grain type, or the occasional presence of mobile groups as well as the sedentary agriculturalists (see discussion in the following chapter). There may also be a relationship between household size or wealth and quern type. The continued importance of small scale grinding equipments (both rotary and saddle querns) does indicate that some level of flour production always took place on a domestic scale.

8.5 The Bone Evidence

The animal bones recovered from the excavations at Jarma were examined by Stephanie Knight and Matty Britton (Britton and Grant forth). As well as species presence they provide some useful insights into the economy of the site. The majority of bones identified to species were recovered from pits, while other feature fills also produced bones, as well as occasional walls and wells fills. In all cases they are likely to represent refuse and food waste. Domestic species dominate the species lists with some wild animals (antelope, gazelle, giraffe, fish, lagomorph and rodents). Sheep/goat and cattle are present in all phases, while occasional dog bones occur throughout the sequence. Camel, pig and occasional horse first appear in phases 7 and

6/7 (1st-2nd centuries AD). Sheep/goat are the most numerous species in all phases, probably representing the major meat component of the diet throughout the period of occupation. Cattle forms the second most numerous group although fall in number from the 1st and 2nd centuries AD while camel and pig increase. Camel particularly increases in relation to cattle from the 8th century AD at the height of the caravan trade (Liverani 2000). The numbers of pigs found within the assemblages do not start to fall until the 15th century AD, despite the proposed introduction of Islam to the area by the 11th century (Mattingly 2003c). Pig bone continues to be represented into the upper phases at the site. The greatest period of species diversity, reflected in the increased presence of birds and wild species, occurs between phases 6/7 and 2 (1st to 16th century). Fish and crustaceans are present from phase 7 and 6/7 some of which presumably representing traded goods from the Mediterranean region. A period of very low species diversity is seen in the 18th and 19th centuries, the period of marked economic decline.

Butchery patterns represented by the bone data appear to have been standardised and extensive throughout all phases and for all the common animals (sheep/goat, cattle, camel, horse and dog). Few complete bones were recovered suggested to indicate marrow extractions and/or the use of bone in stews and soups (Britton and Grant forth). Mortality data indicate that sheep/goat, cattle and camel were kept part their prime meat ages indicating their usefulness for secondary products as well as traction and transport. Pig tended to be culled before 2 years of age, a common trend in pigs which have no secondary products so tend to be killed by the time they reach optimum meat size (Britton and Grant forth).

The presence of giraffe in contexts from phases 7 and 6/7 (1st to 3nd century AD) to phase 5 (3rd to 9th century AD) is of particularly interest, suggesting some importation of sub-Saharan livestock at this time, possibly for northwards trade. Fish bone in a phase 6 deposit and conidae shells (originating from the upper coastal zone of the Mediterranean) in deposits from phase 10 to 2 (Britton and Grant *forth.*) indicate southward trade from the coast, although the scale of trade in such goods is impossible to assess.

The high incidence of sheep/goat in the assemblage and the generalised economy with livestock held past prime meat ages (with the exception of pig) is typical of subsistence economies in Northern Africa. Similar patterns were recorded at Berenice (Barker 1979), and in Tripolitania (Clark 1986). It has been suggested that high numbers of old animals are common on settlements living at subsistence levels (Barker 1979). With a few exceptions the bone data are interpreted as representing a subsistence level economy throughout the period of occupation (Britton and Grant *forth.*). A particularly impoverished period is represented in the 18th to 19th century. A period of slightly increased species diversity and the use of possible Roman butchery techniques in the period 1st to 8-11th century AD, perhaps representing a period of increased sophistication and Roman style dietary customs. This also coincides with the presence of traded livestock or meat (giraffe and fish). Throughout the history of the site mutton is likely to have been the staple meat consumed with some beef, camel, park and chicken. The possible consumption of meat in stews and soups would be consistent with current dietary habits across much of the wider region where meat tends to be cooked in pot in liquid to be served with couscous, rice, pasta or various forms of bread (see chapter 9). Wool is likely to have been produced on a domestic scale as has been suggested for other sites such as Berenice, as sheep from desert environments tend to produce poor quality fleece (Blench 1993). The recovery of large clay loom weights in several phases at the site (loom weights were recovered from phases 6-7, 5, 4 and 3; see chapter 4) would support an interpretation of domestic scale of wool processing.

8.6 Food and Drink in Funerary Ritual: The Mortuary Evidence

An association between food and mortuary features appears to have been a characteristic in the Fazzān from the Late Pastoral period until recently. In Libyan society, as in much of the Sahara, ancestor cults are well attested by both ancient writers and archaeological evidence including enclosures, stele and offering-tables attached to many tombs (Brett and Fentress 1996; Mattingly 1999). While ancestor cults largely disappeared with the adoption of Islam the construction of numerous 'marabout' tombs from the 16th century onwards suggest a continuation of the reverence of graves of significant leaders or holy men (Mattingly and Edwards 2003, 179). Given the prohibition on excavation Islamic period graves there is no evidence of internal placed Islamic period grave goods, although food offerings have been noted resting on the top of recent graves (Mattingly and Edwards 2003). The following brief discussion is therefore largely concerned with prehistoric and Garamantian evidence.

A full discussion of burial types and chronology is given in Mattingly and Edwards (2003; see also Di Lernia *et al.* 2001; Di Lernia and Manzi 2002). The earliest formal burials in the Fazzān appear to be communal and date from the late Pastoral period (c.3000 – 1000BC) and occur in a variety of forms including cairns to antenna tombs. In the Wadi Tanezzuft there appears to be a southwards shift which is chronologically synchronous with a shift from large communal tombs to individual gravels which appears to be associated with new concepts of status and possible new biological populations in the region (Di Lernia *et al.* 2001; Di Lernia and Manzi 2002). Grave goods are rare in this period although a deposit of dates was found in a pastoral period burial in the Wādī Tanezzuft near Ghat, dating to the end of the 2nd millennium bc (Cottini and Rottoli 2002, 174, 179, footnote 19).

By the early or proto-Garamantian period (c.1000 – 500BC) dispersed individual cairn graves of a range of types, were spread in broad zones on the escarpment along the Wādī al-Ajāl, and grave goods were still rare. By the second part of the fist millennium BC, the Early Garamantian period (500 – 1BC) the pattern emerges of nucleated clusters of burials and the emergence of larger and more elaborate 'elite' burials as well as the use of 'proto-stele' and offering vessels in associated with some burials (Mattingly and Edwards 2003).

The Classic Garamantian period (c. AD 1- 500) is characterised by nucleated cemeteries in which status was reflected by the type and scale of monument, wealth and number of grave goods and presence of prominent stele and offering tables for regular offerings (Mattingly and Edwards 2003). The number and scale of cemeteries of this period is extensive and most show some relationship with wadi centre settlements. Elite monuments include mausolea of dressed stone showing clear Classical influences (eg. Mattingly and Edwards, 2003, p. 190 fig. 6.13), pyramid tombs and large stepped tombs. The tight nucleation may be related to tight social controls limiting the spread of tomb construction, particularly where land was limited due to the extent of agriculture, or it may reflect closer social bonds between elite and non-elite members of society (Mattingly and Edwards 2003, 219). Outside the Wādī al-Ajāl Garamantian cemetery sites tend to be less densely nucleated and consist of a more limited tomb type (drum and large cairns) and while they show a similar range of imported grave goods they tend to lack developed offering tables and stele (Mattingly and Edwards 2003).

Stele and offering tables marking tombs are a common feature of classic Garamantian period cemeteries, presumably to enabled continued offerings to and discourse with the deceased. While the stele appear to be a feature confined to the Wādī al-Ajāl, similar offering tables are found in Roman period cemeteries in eastern and central Numidia and are thought therefore to represent a common African tradition (Mattingly and Edwards 2003, 211). The stele consist of upright carved stones described as either 'horns', consisting of v-shaped uprights or 'hands', formed of four vertical and symmetrical 'digits'. Offering tables are variable, although the standard type was a rectangular block with a series of sunken compartments, typically one large and several small, within which could be placed liquids or food.

Classic Garamantian period grave goods typically include imported wine amphorae and drinking vessels including jugs, cups and glass beakers, Italian *sigillata,* oil lamps and faience (Caputo 1937; 1951; Fontana 1995; Mattingly and Edwards 2003; Ruprechtsberger 1997; Tagart 1982; 1983). Other goods include jewellery (both local and imported), head rests, ceramic incense burners, mats and leather shrouds (Mattingly and Edwards 2003). Fontana has remarked on the uniformity of the imported assemblages within tombs, one feature of which is the fragility of the goods, particularly glassware, although the richness is variable (Fontana 1995). This therefore suggests a standardized burial package, the chief components of which are wine amphorae and associated drinking vessels, oil amphorae and lamps. The presence of grinding equipment in grave assemblages has already been noted. There appears to be an emphasis on consumption of both grain products and wine, and possibly feasting reflected in the expensive imported product (as opposed to quantity) and presumably some notion of social elitism. Several burials excavated by Caputo in the 1930s contained food remains and cinders, possibly from food offerings made at the grave site and incorporated in the burial (1951, 407-8). Daniels recorded at least two graves with deposits of carbonized dates at Saniat bin Huwaydi and at Zinkekrā (Mattingly and Edwards 2003).

As yet the latest burials excavated in the Wādī al-Ajāl date o the 5th or 6th centuries AD after which there is something of a gap in cemetery chronology until the Islamic period (1100 – 1900AD). An absence of imported Mediterranean goods by period results in difficulties in recognition and it is likely that some of the tombs in the nucleated cemeteries are of this date. By the Islamic period cemeteries are often located on the outskirts of the villages usually in unmarked areas although sometimes walled. Cemeteries are often established around a *murābit* tomb. Burials tend to be aligned north-south, with an oval mound of stones or earth and an upright slabs of stone at each end (Mattingly and Edwards 2003). Cemeteries of this period are always situated in the oasis floor rather than the escarpment edge.

8.7 Summary

The discussion of artefacts, burial assemblages, bones and structural evidence for ovens from the Fazzān raises some interesting points concerning food production and consumption and the possible role of food and drink in burial customs. The evidence is strongest for the Garamantian and proto-Garamantian period, with far more limited evidence for the nature of Islamic society when imports are greatly reduced and burial evidence largely absent. Despite the decline in imported goods from the late Garamantian period onwards, there are indications of continuity of some elements of social structure. The presence of Quern stones and mortars throughout the occupation sequence at Jarma suggests that flour manufacture and grain preparation remained a domestic activity until recent times when European style bread has been manufactured commercially in village bakeries. The bone evidence similarly suggests continuity in meat preparation and diet with, although a period of increased diversity in diet is seen in the Garamantian period. It is interesting to note the continued use of pig until well after the adoption of Islam.

Food and drink were clearly an important part of funerary customs from the late pastoral period until at least the end of the Garamantian period. Food offerings at recent Islamic graves indicate that it remains significant. It is possible that this reflects the significance of food production in life, and the investment necessary to make sufficient returns. Food offerings, in the form of dates, appear in the late pastoral period at the end of the 2nd millennium BC during which early agriculture must have been attempted in better watered parts of the Fazzān, particularly the Wādī al-Ajāl. Food offerings and offering tables are very much a feature of the Classic Garamantian period during which agricultural production is likely to have reached its peak. It is tempting therefore to suggest a link between agriculture and burial rite including ancestor cults.

Clearly the imported goods, particularly pottery and its edible contents, represent northern influences and highlight the role of Punic and Roman culture on the Fazzān. This is also reflected in the archaeobotanical evidence with the continued introduction of Mediterranean fruits and grain types. Several elements of the artefactual assemblages indicate parallels with other African cultures however and suggest that the adoption of Roman artefacts may in large part derive from their use in indigenous traditions. While the role of artefacts associated with food and drink is difficult to interpret in terms of social structure, it is interesting that it is the wealth of goods which appears important rather than the scale, suggesting luxury rather than abundance. The adoption of foreign alcoholic beverages, particularly by elite groups, is a common pattern and often involves its assimilation into elite culture including religious rites (Dietler 1990; Sherratt 1986). A similar practice in the Fazzān is entirely plausible where certain aspects of Roman material culture, particularly wine and food consumption, appear to have been adopted into existing indigenous practices.

Chapter 9
ETHNOGRAPHIC OBSERVATION IN THE FAZZĀN AND NUBIA

9.1 Introduction
While Ethnographic studies of agricultural activities and food preparation cannot provide a direct comparison with ancient behaviour they do provide a useful tool: analogues with which to form potential hypotheses. Ethnographic observation was made by during field work in both the Fazzān and in the Fourth Cataract in the Middle Nile Valley, Sudan, which included both field notes and discussion with local residents in the fields and the home. Discussion and observation in the Fazzān tended to concern the men, particularly those that worked on site, while in Sudan the author was able to spend considerably more time with the women in the village of El Terif and on the island of Isheshi, providing a privileged in sight into domestic life within a very traditional community. The authors' observations have been supplemented by published accounts in both northern Africa and Jordan, particularly those of J. Nicolaisen (Nicolaisen and Nicolaisen 1997) following field work amongst the Tuareg in the 1950s and 1960s. It is striking that certain characteristics of the arable system are consistently noted across the Sahara. This chapter also includes some observations concerning present day culinary practices in these regions with a discussion of origins of some food types. It is stressed that this is not an exhaustive or in depth study but merely a starting point for potential future direction of study.

9.2 Current Cultivation Practices in the Fazzān
The current agricultural system amongst farmers in the Jarma region is similar to that in much of arid North Africa. Intensive garden horticulture is practiced, in which small plots are cultivated with hand tools. Wheat (*gumar* or *gamir* in Sudan) and barley (*sha'ir*) are sown in October and harvested in April, both crops often being sown in one garden plot in alternate rows. After this first harvest sorghum (*qful* or *durra*) and pearl millet (*qusab*) are sown. Pearl millet is harvested three months later in July and Sorghum seven months later in November or December. The field is then left fallow for one year or peas and beans might be grown. Other winter crops grown are tomatoes, onions, peppers and sesame, while in summer cucumbers, cow peas and maize are cultivated. Dates form a particularly significant crop with other perennial

fruits occasionally cultivated. Manure is added every year in deep layers (fig. 9.1), consisting largely of animal dung particularly from penned sheep/goats.

Nicholaisen and Nicholaisen (1997) record a very similar manuring system in the Ahaggar in which agriculturalists carry fresh soil to the wheat and barley plots throughout the early stages of growth. They distinguish garden soil from manure, although the results would be essentially the same. After three or four years of cultivation the soil is left fallow for a year. In some areas agricultural households spent all day carrying fresh soil to the garden plots, which was then left in small heaps (one in each garden bed) to be spread over and between the green plants. A similar practice occurs in the Fourth Cataract region of Sudan in which several centimetres of sheet/goat pen waste mixed with chaff (*samad*) was added to plots before watering. This practice would appear to be widespread and may well be ancient as suggested by Herodotus who states that the Garamantes 'spread soil [also translated as humus] over the salt to sow their seed in' (Histories IV.183). The stalling of sheep and goats in pens within the settlement, as suggested by the archaeological deposits in Jarma, would then provide a ready source of manure for transport to the fields.

The location of cultivation plots in the Jarma region is today determined by the location of the artesian wells (and in turn by the ease of access to underground water supply), while villages are positioned along the main road through the wadi. Plots are positioned in a band to the north of the villages, around Old Jarma and satellite settlements. The ancient plots may have been positioned further to the south of Old Jarma, towards the *foggara*. Small plots are clustered together in groups which are surrounded by palm trees and fences with occasional other fruit trees planted intermittently. The availability of imported fruits has presumably impacted on the cultivation of fruits locally, although vines were clearly cultivated in the recent past as suggested by old vines still remaining in some fields. The size of plots is necessarily limited by the area which can be manually irrigated, water running freely in channels around the plots when the sluice gates are opened. Manuring and irrigation is conducted by men, while both women and men work in the fields thereafter to weed and harvest.

While today agriculture supports relatively few households compared to in the past, mostly those of older residents, it is possible that it has changed little for several centuries. It is essentially practiced on a subsistence level, intended to support the household. Some surplus product is sold in local markets, particularly green fodder crops with limited storage value and vegetables. Surplus is sold to obtain additional products, although the creation of surplus for market is not the primary goal of agriculture. While farmers are not completely divorced from the market economy, they can still be regarded as 'subsistence' farmers. In addition supplementary forms of income might be sought, including as labourers for European archaeologists. This can therefore be regarded as a labour intensive form of agriculture which may have remained unchanged for centuries. A very similar, although more limited practice was observed in the Fourth Cataract of Sudan, where local weekly markets took place selling a limited range of locally produced vegetables, seed and animals (goat and chickens), most produce going directly into domestic stores.

9.2.1 Irrigation

Irrigation of cultivation plots in the Jarma region is today conducted by wells (*dalw*) which are today powered by diesel pumps. Despite the mechanised wells the plots irrigated remain as small as traditionally watered plots from animal or human powered wells, although the effect is to deplete the fossil water supply at an alarming rate (Wilson and Mattingly 2003, 278). The mechanics of directing water around the plots appears unaffected by mechanised pumps, being conducted by hand and spade through narrow, shallow channels around each plot (fig. 9.2). Small banks of soil are built up and removed as necessary to direct the water. An identical method was witnessed in the Fourth Cataract, Sudan. Here two systems of irrigation were in operation both relying on the waters of the Nile. *Saluka* land is the land on the banks of the Nile which are flooded during July to August, then sown as the water retreats with no further irrigation or manuring. Cultivation of the *saluka* land is therefore labour efficient and more extensive than on the irrigated plots. Crops sown on s*aluka* land were cow pea (grown all year round), white lupin, fûl beans, and pearl millet (*dokhan*). The pearl millet sown in winter did not produce seed but was used as a quick growing animal fodder. The *Saqia* land, above the river banks and on the islands, was watered by diesel pumps in winter and summer for the cultivation of wheat in winter and pearl millet and sorghum (*marek*) in summer as well as onions, fenugreek, clover/birseen (*Trifolium alexandrium*), cumin, haricot beans, tomatoes, pumpkin, potatoes, carrot and okra. Date palms are not watered, and grow on the top of the river banks between the river and the *saqia* land. As seen in Jarma, water is directed around small plots by hand having been raised by diesel pumps, cereal plots being watered once a week. While the diesel pumps assist in raising the water, increasing the amount of land which can be cultivated, they do not actually reduce the labour required to keep the plots watered.

Nicholaisen and Nicholaisen similarly stress that even with *foggara* irrigation arable cultivation is extremely hard work, intensive and frequently produces poor returns in Ahaggar (1997, 258-9). The actual irrigation method of the garden plots is the same regardless of whether the water is supplied by *foggara* or well. Water flows into a large basin through a canal, then out to the garden to be divided into a large number of garden beds. Each bed was surrounded by low ridges and separated by narrow irrigation canals. A large stone with a hole in it was used to control water flow from the basin with a stopper used at night. The irrigation method is most significant for the winter cereals.

9.2.2 Garden Ownership

Nicholaisen and Nicholaisen give further details of ownership and contracts between agriculturalist and Tuareg garden owners in Ahaggar in the 1950s (1997, 265). The gardens were individually tended by the agriculturalists, who cooperate in terms of *foggara* maintenance under the leadership of a headman known as an *amrar n efeli* or 'chief of the *foggara*', appointed by the Tuareg and rewarded with his own garden. The cultivators working together in the same *foggara* were not necessarily from extended families or had any kinship bond. Similarly there were not necessarily kinship bonds between the Tuareg who owned gardens at the same *foggara*, and each Tuareg garden owner may have owned gardens in different locations. However, it was generally the case that Tuareg who owned gardens at the same *foggara* were related by kinship bonds. Contracts between Tuareg garden owners and agriculturalists were for a period of six months, the period of growth for wheat and barley. For his part the Tuareg owner supplied the cultivator with a hoe every year or every two years, paid for repairs to the *foggara* or for digging new *foggara* (for which 2kg of cereals or dates were paid for each working day until the water reaches the garden), and finally they pay for making of new garden beds.

The impression given by Nicolaisen and Nicolaisen's descriptions concerning land ownership is quite different to that gained in the Fourth Cataract region. Here it was stressed that land was more readily available than labour and crops were consequently moved year to year. Cultivation and land ownership was by extended family. Ownership of large metal tools, including cow-drawn ploughs, was limited by finances and these were usually rented or soil was broken up by hand held adze or hoe. Similarly milling appears to have been conducted in village milling machines, of which some villages had as many as three, households using pestles and mortars rather than quern stones. Threshing floors (*taga*) were communal and threshing was conducted either by hand or by a large travelling threshing machine (*dagaga*). There may have been significant differences in the organisation and ownership of land in the past and in the different geographical locations, the Nile providing abundant water and fertile land. The limitation of the irrigation methods in the Fazzān would be the land which could be watered. To this extent the extensive *foggara* would have greatly increased land availability but construction and ownership of the *foggara* and consequently cultivated land may have been tightly controlled or wealth dependent.

9.3 Quern Stones

A number of houses in modern Jarma still retain quern stone emplacements similar to those encountered in the excavation at Jarma. Some older women in the village were familiar with the use of the roughly worked stone rotary querns and were able to demonstrate their use suggesting their use at least until recently. Ethnographic work in Senegal has demonstrated that querns are common wedding gifts to brides and every woman has one, each lasting about 20 years (ethnographic work by Roberto Risch, Dorian Fuller *pers comm.*; cf. Zurro, Risch, and Clemente Conte 2005). As an archaeological comparison, twenty-four of the thirty seven houses which produced sufficient data from the Workmen's village at Armarna, Egypt, were equipped with mortars, while thirty-three had quern emplacements (Samuel 1999, 134). Quern stones and mortars therefore are likely to represent part of the assemblage of domestic equipment that all households involved in flour and bread production would own or aspire to own. On the island of Isheshi in the Fourth Cataract region of the Sudan grain was taken to one of the three village mills for grinding and no hand querns were noted in the houses visited.

In parts of Jordan both settled farmers (*Fallāhīn*) and Bedouin traditionally use rotary querns, while both also rely on mechanized mills (Palmer 2002). Here the extent of use of the rotary mill appears to be cultural and linked to method of grain consumption. The Bedouin who traditionally eat their grain in a coarse ground form as a kind of gruel or porridge (Musil 1908, 153; 1928, 91, in Palmer 2002) rely more heavily on the rotary quern, while the *Fallāhīn* who eat more bread require finer flour and therefore rely more heavily on mechanized mills (Palmer 2002, 177). The ownership of quern stones may then be linked to cultural tradition and grain type as well as wealth or even social structure.

There appears to have been a relationship between mobility and quern type and cultural groups in recent farming and pastoral groups in North Africa and parts of the Near East. The saddle quern (*tehunt*) is traditionally used amongst the Northern Tuareg, used for wheat, barley and some wild seeds, while it is much less common amongst Southern Tuareg (Nicholaisen & Nicholaisen 1997, 314). Rotary hand mills (*tasirt*) are more closely associated with the Berbers and Arabs of Northern Africa, both agriculturalists and nomads. Its presence in the Tuareg regions, for example Ahaggar, is recent and less frequent than the saddle quern, and where they occur they are obtained from sedentary agriculturalists. Other Tuareg groups did not use querns at all but used wooden, or occasionally stone, mortars, which are known throughout Tuareg territory and are used for pounding millet and sorghum, as well as other cereals, wild seeds, dates, cheese, meat, locusts and so on (*ibid.*). The absence of querns in houses in the Fourth Cataract then might be related to the traditional use of sorghum and millet grains which are better pounded in mortars.

It would appear likely therefore that the use of particular quern types or mortars is associated with mobility but also with grain type and use of grain, and therefore has strong cultural associations as well as wealth implications. In sedentary groups the use of quern stones as opposed to mortars may be closely associated with wheat and/or barley flour, while mortars may have a stronger association with sorghum and millets, or for pounding of hulled cereals including emmer. The manufacture of rotary querns is time consuming and may therefore be associated with sedentary groups or semi-nomadic groups rather than pastoralists. The relationship between grain use, wealth, household size, social structure and quern type is an interesting one which will hopefully be explored with further field work in this region and others in Africa.

9.4 Food and Cuisine

As discussed in the previous chapter food and the way in which it is prepared and consumed is strongly affected by cultural tradition. Typical national dishes such as pasta in Italy, couscous in the Maghreb and roast dinners in the UK have strong national identities and even distinct regional variations. Grain foods, particularly bread but also pasta, rice, couscous and so on have particularly strong cultural affinities which are likely to be ancient in origin and may be closely associated with particular grain types or grain characteristics. Movement of people, both due to migration and vacation travel is a prime agent of transfer of culinary ideas as well as arable traditions, themselves often strongly associated with cuisine. The range and character of a nations cuisine will consequently provide some clues as to the demographic history of that nation. The diverse range of cuisines seen in the USA or the UK today can be linked to the long tradition of immigration and the countries or regions from which immigrants have traditionally originated. Similarly the cuisine of much of the Maghreb has been influenced by Italian, British and French cuisine as well as the spread of more indigenous traditions across the region such as couscous (see below). As such the traditional cuisines of the Fazzān might provide some clues as to the movement on populations and the dynamics by which certain crop plants or types spread across the region, particularly where this can be linked to artefactual evidence for food technologies (bread ovens or *dokas*, *couscoussières* and so on).

9.4.1 Bread

In its most simple form bread is made from moist dough of the flour of milled grains and water or milk, possibly leavened, and baked, with or without direct exposure to fire. A wide range of variations in terms of ingredients (grain type, leavening agent), processing methods (fermented, leavened), forms (flat bread, moulded loaves, pancake bread) and baking technology (flat plates, in embers, bread ovens) exist which are closely associated with cultural tradition and grain type. In addition the scale of production of bread in terms of both flour production and baking (as a domestic product or in communal mills/ovens) may be closely associated with economic factors and social interactions as discussed by Samuel in relation to the Armarna Workmen's village, Egypt (1999). The archaeological evidence from Jarma suggests *dokas* and *tanur* type ovens were used to make bread in the past. Other forms of bread making may also have taken place which left little impression on the archaeological record.

White European style wheat bread has become a staple in the villages of the Fazzān, bought from central bakeries, as it has in much of northern Africa, more traditional forms of flat bread are still made for domestic consumption. Two basic types of flat bread are produced across the northern Sahara and the Nile Valley, dough bread, either leavened or unleavened, which is comparable to flat beads made in much of the Near East, and liquid pancake type breads. Flat dough breads are produced in a range of methods including ovens, platters, pans and in the ashes of fires. The liquid pancake breads are made on metal sheets or in ashes. In the Middle Nile Valley both bread types are cooked on metal sheets (previously ceramic *doka*), the dough bread usually made from wheat and known as *garasa*, and the pancake bread, *kisira*, usually made from fermented sorghum or pearl millet. *Kisira* is very similar to the Ethiopian *injera* made from fermented tef, and according to Edwards such fermented breads have a limited distribution (Edwards 1996b). The northern Tuareg make a flat bread, *taġella*, made from a batter or thin porridge rather than a dough, directly in the hot embers and ashes (Gast and Adrian 1965; 32-33; Nicholaisen 1963; Nicholaisen and Nicholaisen 1997, 319-320) which may be similar to *kissira*. The northern Tuareg make flat dough bread in the ashes (*pers. obsv.*) known by the generic term *khubz* (Nicholaisen and Nicholaisen 1997) which is presumably similar to flat bread made Bedouin men in Jordan in the ashes known as *gurs al-nar* or *arbud* (Palmer 2002). Palmer notes (2002, 179) that bread baked in ashes is strongly associated with men in Jordan as it appears to be amongst the Tuareg (*pers. obsv.*), while platter and oven breads are more strongly associated with women. While wheat bread is the staple of the northern Tuareg, bread is also made from barley or from wild seeds (*Chenopodium vulcaria, Aizoon canariense*, *Aristida pungens* and roots of *Cistanche phelupaeae*), where as millet and sorghum are considered less suitable for bread (Nicholaisen and Nicholaisen 1997, 318). The Ayr Tuareg conversely do not produce bread as a staple, but those that do use 'millet and wild seeds' to make a *taġella* or *tugella* bread in embers and ashes, or they make *gurasa*, a dough bread made of the sides or bottom of a metal pot heated over a fire (Nicholaisen and Nicholaisen 1997, 230). A very similar tradition to that in Sudan appears to be described here.

Across the region therefore there are three types of bread: European style bread, a range of flat dough breads baked in ovens, on platters, in a pan, or in ashes, and breads made of liquid dough of various types including the *taġella* or *tugellai* of the Tuareg and the fermented sour dough pancake bread in the Middle Nile Valley and Ethiopia. It has been suggested by Lyons and D'Andrea (2003) that bread baking technology is related to performance characteristics of different grain types and as such can be used to trace development of bread in regional cuisines. The higher gluten cereals, wheat and barley in particular, produce dough that is both viscous and elastic and can therefore be hand formed and baked on walls floors or trays within an oven. Further more leavened bread is best baked in an oven. *Tanur* type bread ovens are consequently closely linked to the Near Eastern cereals and tend to be found in regions where these cereals have traditionally been used for bread baking. Starchy ingredients with low gluten content are more suited to bread made from a batter cooked on griddles. Such foods include the African cereals (tef, sorghum, pearl millet, finger millet), tubers (e.g. ensete), the American cereal maize and other ingredients such as sweet potato, manioc and so on, and forms of griddle bread are consequently found globally. The adoption of bread making technology may therefore be linked to traditional local ingredients as well as mobility. When new cereal types are adopted by a population with a well established bread making tradition it is likely that they simply incorporate the new crops into their existing technology. For example, the *tanur* is absent in first millennium BC Ethiopia despite the cultivation of emmer wheat, hence it appears the Ethiopians adapted Near Eastern cereals to an African baking tradition. Similarly in Yemen, sorghum and pearl millet were baked in *tanur* suggesting they were adopted into a Near Eastern bread making tradition.

Lyons and D'Andrea argue that in Highland Ethiopia griddle baking emerged with indigenous subsistence practices based on tef, finger millet and other starchy foods, and later adopted the Near Eastern domesticates into an existing socio-technical system of cereal production (Lyons and D'Andrea 2003). The paucity of the ceramic griddles prior to the mid-first millennium BC is not adequately explained, but may simply be a result of poor archaeological representation in early sites. They do argue, reasonably, that the replacement of metal by ceramic griddles is unlikely (*contra.* Wilding 1989, 308). The absence of any obvious early bread making technology in the Fazzān when it is so evident in New Kingdom Egypt may relate to a predominantly mobile lifestyle prior to the introduction of the Near Eastern cereals with a reliance of wild indigenous starchy grains. Rather than the bread oven being adopted with emmer wheat, emmer bread may have been produced in a fashion similar to that of the Northern Tuareg or Jordanian Bedouin in hot embers or on heated stones or platters, or it may indicate the use of grain as a gruel or porridge rather than bread. The arrival of ceramic *doka* in the Garamantian period may be associated with the introduction of sorghum, as suggested for Sudan (Edwards 1996), and millet and would therefore represent a late diffusion into the northern Sahara and into Sudan. Certainly the tradition of fermented pancake type breads seems to be closely associated with millet type grains across parts of the Sahara and the Nile Valley and a strong cultural link may be envisaged here.

9.4.2 Non-Bread Grain foods

Grain staples are widely consumed in non-bread form across much of North Africa. The most significant and well recognised of these is couscous, particularly in the Western Maghreb where it is eaten as a staple as well as a feast food. Couscous consists of grain made from semolina, traditionally made from durum wheat, but also from barley or millet. Small granules of coarsely ground grain are sprinkled with water and rolled with the hands to form small pellets, then sprinkled with dry semolina flour to separate the grains. The couscous is sieved and small granules which pass through the sieve are sprinkled with dry semolina and rolled again. Once made, the couscous can be dried in the sun and stored for several months. The time consuming nature of couscous making is such that it tends to be conducted as a communal effort with several woman coming together from an extended family (Noakes and Noakes 1998). The couscous is cooked in a steamer over a sauce and is traditionally steamed three times. While a metal *couscoussière* is used today, a ceramic or organic container could also have been used. While not a staple of the Tuareg it is eaten amongst some northern groups, known as *keskesu* and it is steamed in ceramic, pottery or woven baskets (Nicholaisen and Nicholaisen 1997, 328). It is widely eaten in Libya and the Maghreb but not in Egypt or Sudan.

Now widespread, the early history of couscous is unclear but it is generally regarded as Berber in origin, possibly with sub-Saharan, West African antecedents. The once widely held belief that it was an Arabic introduction may be in part associated with the (incorrect) belief that durum wheat was introduced by the Arabs in the 7th century AD (e.g. Watson 1983). Noakes and Noakes (1998) believe the Arabic world *kuskus* is derived from the Berber *seksu*, suggesting a pre-Arab origin in North Africa (1998). The Berber name *kesksou* is said to be derived from the sound steam makes as it passes through the grain (Roden 2005). Bolens believes it to have originated from the end of the 1st millennium BC, based on the presence of primitive couscous pots found in tombs dating to the reign of the Berber king Massinissa of Numidia (238-149BC) (Bolens 1990; 1989, 61). Charles Perry conversely believes couscous originated between the end of the Zidrid dynasty and the rise of the Almohadian dynasty, between the eleventh and the thirteenth centuries (Perry, 1990, 177). By the 13th century it appears to have been widespread, presumably largely due to Moorish expansion during this period, and it features in several Arabic culinary manuscripts of the Maghreb and Andalusia and further a field. Two 13th-century Andalusian authors refer to couscous: Ibn Razin al-Tujibi in his book *Fadalat al-Khiwan fi Tayyibat al-Ta'am wa 'l-Alwan* (Delights of the Table and the Best Types of Dishes) and an anonymous 13th century Hispano-Muslim writer in *Kitāb al-tabīkh fī al-Maghrib wa'l-Andalus*, in which a couscous recipe is referred as being 'known all over the world' or 'known to everyone' implying its widespread use by this time. There is some belief that the process of steaming over a broth may have originated in West Africa. For example Ibn Batuta, travelling to Mali (now Mauritania) in 1352 had millet couscous (Ibn Batuta 1929). Couscous type dishes are prepared in many millet growing areas, for example from fonio grain (*Digitaria exilis* and *D. iburua*) in Nigeria and Benin, or from pearl millet across the Sahel regions (BSTID 1996). This raises the possibility that it originated in West African millet eating areas and was absorbed into Berber or Moroccan traditions reaching wider geographical spread with its subsequent association with durum wheat.

Certainly couscous is a dish of great significance in the Maghreb which in Morocco has an almost mythical, magical character (Roden 2005). It is both a staple and a celebratory food. The timing of its introduction to the Fazzān is unknown. Durum wheat appears to be present from the Garamantian period (1st to 2nd centuries AD) and there is no evidence that it is a Berber rather than a Roman or Egyptian introduction. It is possible that couscous was not introduced until the 15th or 16th century with the arrival of a number of *Ashrāf murābiṭūn* (Mattingly 2003b, 99), possibly associated with a general migration of Moroccan *murābiṭūn* families after the defeat of a revolt at Fez (el Hesnawi 1990, 41-47; cf. Brett 1981; 1984).

Various porridge type dishes based on cereal flour appear in parts of Africa, such as *bazeen* or *bazin*, in Libya and *Assida* in Sudan. *Bazeen* is a hard paste like food usually made of barley flour, water and salt which is boiled in water, homogenised, re-boiled and served in balls with meat or gravy and frequently eggs. In the Fazzān a mixture of sorghum and barley or pearl millet are also used for *bazeen* (*pers. comm.* from locals in Jarma). The dish is described by travellers to the Fazzān including Despois, (1949, 190) and Lyon, (1821, 49), while Hugh Clapperton travelling in the early 19th century was fed 'fowels and bazeen' (Bruce-Lockhart and Wright 2000, 52). *Assida* in Sudan is a similar congealed starchy dish made by pouring sorghum flour into boiling water and stirring until the water is absorbed. This is the staple dish in much of Sudan, traditionally served with *mulha*, a sauce made of onion, okra, dried meat, dried tomatoes, salt and chilli. *Toh*, a stiff porridge made from pearl millet is consumed across the northern Sahel (BSTID 1996). Both the Ahaggar and Ayr Tuareg make a millet porridge, known as *esink* in Ahaggar and *echink* in Ayr, usually eaten with milk or vegetables if milk is scarce (Nicholaisen and Nicholaisen 1997).

9.4.3 Alcohol and Fermented Foods

Fermentation is widely used to sour cereal foods in Africa particularly associated with sorghum and millets. Examples of fermented foods include *bogobe* (sour sorghum porridge) in Botswana, *nasha* (sour sorghum and millet porridge) in Sudan, *obusera* (sour millet porridge) in Uganda and *koko*, a sour dough porridge of pearl millet in the Sahel (BSTID 1996). As discussed above sour dough bread is produced in Sudan (*kissra*) and in Ethiopia (*injera*). The role of beer in African societies is known to be particularly significant, both in terms of its calorific and nutritional value, but also its symbolic and social importance. The consumption of beer is a social act which is associated with hospitality, social ties, maintaining social hierarchy and bonds, labour mobilization, marriage arrangements, status and wealth and so on (e.g. see Arthur 2003; Dietler 1990; Karp 1980; Mandelbaum 1965; Netting 1964). Considerable labour and time are spent processing grain to beer, in part in order to establish alliances and creating reciprocity in the form of labour and social and economic coalitions (Arthur 2003). Beer is particularly associated with mobilization of labour in societies where wealth is closely related to the availability of productive labour rather than other forms of wealth such as material goods or land ownership, as has been suggested for Meroitic society (Edwards 1996a; 1996b; 2003).

The actual process of fermentation raises the nutritional value of sorghum, adding vitamins and increasing the availability of minerals, particularly iron, neutralizing tannins and hydrolyzing the starch to a more digestible form (BSTID 1996). The link between sorghum, millets including tef, and fermentation is likely to be closely associated with cultural groups and the recognition of cultural artefacts associated with fermentation may assist in understanding the nature of the diffusion of these crops. Ethnographic evidence suggests large jars have a strong association with production and consumption of beer, for example among the Gamo in South-Western Ethiopia who use jars which are on average 33.6 litres in volume (Arthur 2003, 522). There is no current tradition of beer consumption in the Fazzan which suggests if sorghum was introduced to the region with sorghum beer drinking populations the tradition may not have entered common culinary customs and sorghum is today used as a snack food or a fodder crop. The possibility of sorghum or other beers being contained in the globular jars in the archaeological record (Chapter 8) would imply some beer production in the past although the extent is difficult to establish. The positive recognition of beer jars would depend on residue analysis. Conversely in Sudan, while beer is no long consumed the continued production of fermented foods in the form of *kissira* is linked to a long history of sorghum and millet cultivation and human consumption (Edwards 1996b). Thus it is possible that while sorghum and millet have become ingrained in the diet and customs of the Middle Nile Valley their adoption into Fazzanese culture and cuisine has been less complete, although some consumption as beer may be suggested the globular jars.

In addition to grains and grape, date and date palms are also traditionally used to produce alcoholic (and non-alcoholic) beverages. In the Fazzān *laqbi* is made from the fermented juice of the date palm, tapped from the trunk just below the crown. A clear spirit (*aragi* in sudan*)* or date wine, is produced from fermented dates in both regions and across much of North Africa. Also in Sudan a cloudy 'beer' known as *dakai* is produced, while a non-alcoholic drink, *sherbol* is produced during Ede. References to the consumption of *laqbi* occur in various travellers accounts to the Fazzān from the 19th century (e.g. Bruce-Lockhart and Wright, 2000). The consumption of date wine and *laqbi* often appears to be negatively associated with drunkenness and generally less sociable than the consumption of wine or beer. There are several references to members of Claperton's travelling party being drunk on *laqbi* (*ibid.*). Given the long history of date cultivation it is highly possible that alcoholic drinks from date are also ancient.

9.5 Summary

This chapter has presented a range of ethnographic observations of arable practices in the Sahara and Sudan with a brief discussion on food and cuisine. The intention of referring to ethnographic evidence is not to provide a method of interpreting the archaeological evidence but is to produce possible hypotheses concerning ancient practice. In particular the character of subsistence based oasis horticulture or garden agriculture is apparently largely consistent across the region in terms of plot size, manual labour, manuring and watering. There is also broad consistency in crops cultivated although the range of crops is more extensive in Nubia than in the Fazzān. The nature of land ownership and wealth in things or wealth in people has been raised as potentially significant in the past. In the Middle Nile Valley land is abundant while possession and labour is scarce. Conversely in the Fazzān the transfer of water to the arable plots may be more labour intensive than in the Nile Valley and consequently position of plots and therefore ownership of plots and *foggāra* (or wells) is more complex. Amongst the Tuareg of the Ahaggar this is further complicated by the system of land and slave ownership in which landowners are not farmers but take payment from the farmers. Again the Ahaggar system suggests land is at a premium and has a high value even to mobile, non-farming populations, which is presumably related to irrigation requirements. The issue of wealth and ownership of labour and/or land is a complex one which is difficult to explore archaeologically, and the ethnographic accounts suggest variation even within 'simple' subsistence societies. Further more cultivation of the river banks in the Nile Valley is an extensive and labour efficient method of cultivation not requiring manure or irrigation, which is unavailable to the occupants of the Fazzān. This therefore allows greater focus on the *saqia* land and potentially more emphasis on high value crops. The description of irrigation methods suggest that irrigation is always intensively managed even with the assistance of the *foggara*. It is therefore suggested that the advantage of the *foggara* is the extent of land brought into cultivation rather than the ease of cultivation and its success would rely heavily on labour.

The discussion of culinary traditions raises some possible hypotheses concerning grain types and treatment of grain. The range of bread types and methods of bread making and the role of beer and methods of bread and fermented sorghum and millet types suggests that while there are some cross over between the Tuareg traditions and those of the Middle Nile Valley these do not necessarily translate into Fazzanese traditions. It is possible that the use of fermented sorghum and millet foods in the Middle Nile Valley is long and associated with the very ancient use of wild sorghums and millets. This may also be the case in the central and southern Sahara amongst mobile groups. In the Fazzān the hypothesis is raised that sorghum and pearl millet were adopted into an existing cereal regime more broadly based on wheat and barley and more characteristic of Mediterranean or Egyptian traditions. This does not mean that sorghum and millet were not introduced by sub-Saharan populations with distinct culinary traditions, merely that the traditions have not filtered into society as widely as they appear to have done elsewhere. Thus, while some globular jars occurring in the archaeological record, they do so alongside wine and do not occur in the vast numbers that they do in the Meroitic sites, and similarly the Fazzān lacks the range of fermented foods seen in societies where sorghum is more central to the diet. Other culinary traditions such as couscous must be associated with the diffusion of cuisines from Morocco, but this cannot be directly linked to the spread of durum wheat which appears to be separate. The origins of couscous may indeed be linked with millet producing regions of West Africa and be more ancient that the cultivation of durum wheat.

Chapter 10
AGRICULTURE, FOOD AND TRADE IN THE WĀDĪ AL-AJĀL: LONG TERM AGRICULTURAL ADAPTATION AND SURVIVAL IN THE LIBYAN SAHARA

10.1 Introduction
This thesis has generated a major new dataset of plant macrofossil records from the central Sahara which, to date, is the only dataset to span almost the entire period of agriculture in the region. The data have been used for two principal aims: to trace the temporal and spatial diffusion of crop species across the central Sahara, and to explore the character of agricultural and social structure within the Wādī al-Ajāl, particularly of the elusive Garamantes. This concluding chapter brings together the evidence so far discussed. Models are proposed for the nature and scale of arable production in the region as well as for the dynamic relationship between the population of the Wadi al-Ajal and surrounding regions including those on the fringes of the Sahara.

The archaeobotanical remains from Jarma, together with those from Zinkekra and Tinda B cover a time period of nearly three millennia. This period is one of changing hydrology (a drop in water table and reduction in available water at or near the surface), and also appears to be one of changing or evolving cultural traditions. The transitional period from pastoral herders to agricultural Garamantes may have been one of increased population movement, with palaeoberbers moving to parts of the Sahara from the Mediterranean or eastern oases (Camps 1980; Brett and Fentress 1996; Muzzolini 1984). Agriculture may have been introduced to the area with migrating peoples, although as archaeological evidence for this transitional period is as yet illusive it is not clear how any such diffusion occurred. By the beginning of the 1st millennium BC agriculture appears to have been well established, based on the Near Eastern staples of wheat and barley with perennial fruits, while the cultural artefacts and burial rites suggest a fusion of indigenous and new traditions. The Garamantian period may have seen the evolution of an early Saharan wide trade network (Liverani 2000a; 2000b; Bovill 1968; Law 1967; Fontana 1995). It also appears to be one of increased social hierarchy and conspicuous wealth as suggested by funerary types and associated burial goods, and a period of large scale importation of manufactured goods from the Roman world (Mattingly 2003 for an overview;

Daniels 1970a; Liverani 2000b). The 1st and 2nd centuries AD represent an apogee of Garamantian culture with a peak in the quality and quantity of imported goods and maximum population expansion (Mattingly 2003; Daniels 1970a). The Late Garamantian period (3rd to 9th century AD) represents a broad continuation of the Classic Phase but with an increase in defensive structures and a decrease in the quality and quantity of imported Mediterranean goods (Mattingly 2003). The post-Garamantian period is less well represented materially but is known to have involved the introduction of Islam, although possibly not widely adopted until the 10th century AD and the fragmentation of the Old Garamantian kingdom and increased political friction (Mattingly 2003). There was a decrease in the number of sites although some 'urban' sites, including Jarma, continued to be occupied, while the focus of economic activity shifted to Zuwila and Murzuq to the south east of the region. A change from expansive cultivation with *foggara* irrigation to more isolated clusters of fields around wells appears to have occurred during this period, possibly from the 11th century onwards and presumably arising from a combination of declining economic fortunes and consequently labour and population, and a continued drop in the water-table (Wilson and Mattingly 2003). The early modern period was one of continued economic decline. The accounts of 18th and 19th century travellers provide a picture of a greatly impoverished region with abandoned, crumbling villages, disease, particularly malaria, and the bulk of agricultural produce being taken as taxes and rents by absentee *shaykhs* and Turkish officials (Barth 1857; Bruce-Lockhart and Wright 2000; Denham and Clapperton 1965). The introduction of New World crops demonstrates that despite the poverty and the shift of trade routes to the west or east, the region was not cut off from outside influence.

10.2 The Nature of Agricultural Production in the Fazzān

This section examines evidence for the scale and intensity of arable production in the Fazzān and examines the potential for exploring aspects of social structure in relation to agricultural production and particularly if terms such as 'subsistence' or 'market economy' are appropriate. The identification and understanding of productive intensification is central to many debates about subsistence change and the development of surplus production and the growth of social-political hierarchies of proto-urban or urban settlements (e.g. Renfrew 1989; Sahlins 1957; Boserup 1965). It has generally been assumed that in some part agricultural production is linked to the economic success of the Garamantes, which in itself is reflected in the rich (predominantly) Mediterranean cultural artefacts, particularly in the 1st and 2nd century AD. While oasis agriculture must always be intensive in nature, requiring significant irrigation and fertilization, the level of intensity and scale of production before, during and following the Garamantian period is a central issue to this thesis and whether or not such increases can be detected within an oasis system. If any increase in intensity or scale of production can be detected, is this related to population growth (e.g. Boserup 1965), or some other factor such as economic or bureaucratic forces and the emergence of a social elite? Can we detect a decrease in intensity or scale of production in later periods as social cohesion in the region collapsed?

10.2.1 Crop Processing Activities as an Indicator of Economic Status

Crop processing activities and the presence of crop processing by-products (chaff and straw and weed seeds) have frequently been used to suggest the economic status of past communities or sites. The issue of consumption or production of agricultural products and the applicability of various models has been much discussed in the literature, particularly in relation to the British Iron Age, and is closely associated with the interpretation of social stratification and site hierarchies (e.g. Hillman, 1981; 1984; M. Jones, 1985; Stevens 2003; Van der Veen and Jones 2006).

The by products from early stages of wheat and barley crop processing (winnowing and coarse sieving) are present throughout the sequence of deposits at Jarma (with the exception of the generally poorly represented early phases 8-10). Winnowing and coarse sieving by-products of pearl millet and sorghum are present in the upper three phases, largely preserved by desiccation. As these early stages of crop processing tend to take place on threshing floors near the fields where the cereals were grown this would indicate that the by-products were being brought into the site for use as fuel, fodder and/or temper or other unrecognised uses. This suggests that the use of crop processing by-products may have remained unchanged throughout the period of occupation at the site, regardless of the changing economic fortunes and political or social structure of the site and region. The residues of cotton processing are also present (the seed) in the Garamantian phases 6 and 5 and early Islamic period. It has been suggested that the consistent but low numbers of cotton seeds are indicative of casual waste from routine domestic processing of the cotton. The scale of cotton processing appears to be in contrast to early Islamic deposits at Volubilis in Morocco, for example, where much greater numbers of cotton seeds concentrated in a few adjacent contexts may indicate some more semi-industrial processing (Fuller, Pelling and De Varailles *forth.*).

The presence of early stage crop processing by-products is difficult to interpret in semi-urban sites in terms of socio-political organisation due to the probable use of chaff and straw as an economic resource in its own right, particularly for fuel, but also for animal feed and as temper in building material. This phenomenon is particularly widespread in arid regions with limited alternative fuel or fodder sources, and appears to have been so in the past (Van der Veen 1999a), and in some instances chaff and straw may be imported into a non-arable site from elsewhere. While the occasional presence of cotton seeds or fruit remains can be regarded as casual waste thrown into fires on a piecemeal basis, the bulk of the cereal processing waste recovered at Jarma can be interpreted as intentional local use of the chaff as a resource (Van der Veen 1999a). As discussed in chapter 6, chaff has clearly been used at the site as fuel, animal feed and probably temper. As yet it has not been possible to explore the relationships between the site of Jarma and contemporary sites within the Wādī al-Ajāl and it is possible that at some points in its history the population of the site were not directly involved in cereal production but were receiving goods cultivated at surrounding sites. The consistency of the patterns observed however might suggest there was little change in terms of cereal production and that the population of Jarma may always have cultivated their own cereals in fields surrounding the settlement. It is not therefore possible to use the plant remains to argue for specialised activity at Jarma (e.g. craft production or cereal cultivation). The evidence for fodder in Garamantian period levels (see Chapter 6) at the site suggests animals were kept within the settlement or that dung was at least an easily obtained fuel. As ethnographic observation from the region suggests this pattern of deliberate local use of chaff and dung resources is consistent with both subsistence level agriculture and urban or semi-urban communities not directly involved in arable production and cannot therefore be used to interpret the nature of society within the site.

10.2.2 The Scale and Intensity of Production

The scale and intensity of agricultural production are related to the way agricultural products are produced and used but also to the way in which society is structured, which includes the relationship between producers and market economies. Of particular interest in relation to the current thesis is the identification of increased arable productivity over time, or indeed decreased productivity, for example with declining wealth or falling water table, and the identification of the nature of any increased productivity (increased intensity of production or expansion of land cultivated etc). If any increased (or decreased) productivity is detected how did it relate to social and economic development, particularly increased social hierarchy, population growth and so on?

While the cause of increases in the scale and intensity of production have been much debated by archaeologists and anthropologists (e.g. Boserup 1965; Leach 1999; Morrison 1994; 1996; Netting 1993), far less literature has been dedicated to identifying it in the archaeobotanical record. Relating any identified changes in the scale and intensity of production with socio-economic causes presents a further potential area of difficulty. The recognition of intensive forms of agriculture (in which increased input into a set unit area of land results in increased output) in the past may be based on three lines of evidence (following Van der Veen 2005): the physical remains of intensification including field walls, terraces or irrigation systems; evidence for soil manipulation particularly the addition of compost or manure which can sometimes be detected through geochemical analyses of old soil horizons and midden deposits (e.g. Bull *et al.* 1999; Evershed *et al.* 1997; Miller and Gleason 1994); and finally through the plant and/or faunal remains themselves, particularly ecological information provided by arable weeds (e.g. Bogard 2005; Scarry and Scarry 2005; Van der Veen 1992b). Morrison (1994) suggests three distinct forms in which intensification may take place and which might be detected in the archaeological record: intensification proper in which increased input per unit of land in terms of ploughing, manuring and so on leads to increased output; specialisation or the reduction of diversity which might involve agricultural specialisation in a particular crop, which in turn would imply exchange and consequently changes in the economic and social systems of a site or sites; and finally diversification in which there is an increase in the number of components of a productive system, which might include staggering planting and harvesting times, or changes in the mix of crops cultivated.

10.2.2.1 Identifying Changes in the Scale and Intensity of Production: the Plant Remains

The archaeobotanical results from the Wādī al-Ajāl demonstrate a shift from a regime relying on winter cereals (those which rely on increasing day length for seed formation) and perennial fruits to a two-cropping system whereby summer crops (those which rely on shortening day lengths for seed formation) were cultivated in addition to the winter ones. This shift appears to begin towards the end of the 1st millennium BC with the introduction of sorghum and pearl millet and continues in the early 1st millennium AD with the introduction of cotton. While diversification is not necessarily synonymous with intensification, where an additional cultivation season is introduced this would imply a more intensive and productive use of land. Providing sufficient manure is added to the soil and fallow periods are incorporated as necessary, a two-cropping system allows a summer crop to be sown once the winter crop has been harvested on the same plot of land. It is also significant that the introduction of the summer crops appears to be part of a general increased diversity of food and non-food crop plants. The fact that the arrival of these new crops appears to be associated with the introduction and construction of vast numbers of *foggara* would imply that this is part of a period of increased emphasis on arable production, presumably with increased productivity. It is therefore suggested on the basis of the crop plants that a period of increased arable diversification which can also be regarded as more intensive, took place in the Garamantian period and continued into the early 1st millennium AD with the introduction of cotton.

While the range of perennial fruits and the cultivation of cotton have largely disappeared, other new crops including chilli and maize have been added to the crop repertoire over time. A diverse and intensive crop repertoire has in fact continued until the present day, as is also seen elsewhere in northern Africa, for example in the Middle Nile Valley (Nubia). The cultivation of a diverse range of crops can be regarded as typical of subsistence or near subsistence based agriculture and in itself does not imply substantial increases in production, but could merely be seen as an adaptive strategy designed to limit risk of crop failure. It is therefore likely that while the initial adoption of new crops occurred as part of a period of expansion of arable productivity, and the disappearance of possible 'luxury' crops (cotton, some fruits) might be related to declining wealth, it is not simply a case of increased diversity for increased production. What must be significant however is the fact that these new, summer crops were introduced at all and the timing at which this introduction occurred. This is discussed in more detailed below.

Weed seeds are a more reliable method of identifying increased intensification (e.g. Bogard 2005; Scarry and Scarry 2005; Van der Veen 1992b). However, the physical requirements of the soil in the Fazzān are such that intensive manuring and irrigation must always have been necessary. Identification of changes in intensity of production is therefore difficult to detect on the basis of weed seeds, compounded by the limits of the ecological ranges of the plants represented and the limited range of species identified. It was not possible therefore to satisfactorily explore aspects of soil fertility and weed floras in relation to intensity of production in the Wādī al-Ajāl other than to suggest possible evidence for increased manuring in terms of an increased number of seeds of *Solanum* sp. in the Classic and Late Garamantian phases (Chapter 5). Interestingly the weed data actually suggest decreased moisture levels over time despite the introduction of the *foggara* with a far greater proportion of wet ground species from Zinkekra (Van der Veen 1992a) than the Jarma assemblages. This would support the interpretation that while the spring line at the foot of the escarpment appears to have no longer been active by the beginning of the 1st millennium BC (Drake *et al.* 2004) there appears to have been sufficient moisture near the surface to enable agriculture. Irrigation does not appear to have affected the wet ground component of the weed flora.

10.2.2.3 Identifying Changes in the Scale and Intensity of Production: the Irrigation Systems

The most visible evidence for the scale of arable production in the Garamantian period is the vast number of *foggara* within the Wādī al-Ajāl and outlying regions. Some 550 or more *foggara* systems are known in the Wādī al-Ajāl alone, and even taking into account the fact that they may have existed over a period of several centuries they are indicative of substantial irrigation potential and consequently agriculture. There is good reason therefore to link the period of population expansion and obvious flourishing of culture with the agriculture afforded by the *foggara* and the diversity of crops as discussed above. While the *foggara* in themselves cannot be credited with the emergence of Garamantian wealth, they are symptomatic of a period of innovation and agricultural expansion. There can be no doubt given the scale of the irrigation systems and the apparent boom in population as suggested by settlement and funerary archaeology (Mattingly 2003), that a period of some agricultural expansion occurred during the Classic Garamantian period, although the scale is difficult to assess.

It is not clear how either *foggara* construction and maintenance or agricultural labour and land were organised either during the Garamantian period or later. As discussed in the previous chapter the *foggara* may not actually reduce the amount of labour required to water the garden plots, rather they expand the area of land brought into cultivation. In contrast, the construction and maintenance of *foggara* and the subsequent farming and irrigation of the plots implies an increased labour force. As Wilson and Mattingly point out (2003, 275) the large number of *foggara* in the wadi, imply a substantial labour force and a sizeable population maintained by the irrigated land. *Foggara* construction might have involved specialised skilled diggers, either as a professional class, as is known in Persia, or specialist *foggara* slaves such as the *haratin* who constructed and maintained *foggara* in the southern Algerian oases until their liberation by the French in the early 20th century (Wilson and Mattingly 2003; Keenan 1977, 147, 174-75, 248-40). It is believed that, given the northward trans-Saharan trade of slaves in the recent historic period, trade in human traffic may also have been significant in earlier times (Wright 1998). Herodotus's reference to Garamantes hunting Ethiopian troglodytes (Histories 4.183-4) is usually interpreted as slave raids. The decline of the Mediterranean trading ports in the 3rd century AD appears to have had a direct effect on the trade of the Fazzān, and a significant decline in imported Mediterranean goods. If the markets were affected, including the supply and demand of slaves, this may be associated with the decline in the maintenance of the *foggara* (Wilson and Mattingly 2003, 277).

In summary, the range of crop plants themselves indicate a possible period of intensification in the form of increased crop diversity to include two cropping season, but they can not be used to demonstrate a significantly more intensive form of agriculture to the garden cultivation practiced in the region today. Similarly, the number of *foggara* does not necessarily imply a substantial difference in intensity of irrigation, but rather an expansion of land. The evidence of the plant remains and the ethnographic evidence therefore suggest that the actual arable practices and the level of intensity may have changed little since the Garamantian period, although the amount of actual land under cultivation was clearly far greater in the Garamantian period than either before or since. While some increased intensification of production may have been achieved it was an expansion of arable land through the introduction of *foggara* and the introduction of new crops which should be regarded as the significant innovation in the Garamantian period. The decline in arable productivity in the post-Garamantian period may not have been particularly acute until the last few centuries when population numbers declined significantly, although a reduction in the amount of land cultivated is likely at an earlier date as the *foggara* fell out of use and were replaced by irrigation from wells.

10.3 Food as Cultural Artefact: Luxury, Conspicuous Consumption and Daily Staples

This section discusses the evidence for food as a cultural artefact and what it contributes to our understanding of social structure. The burial evidence, particularly from the Classic Garamantian period indicates the significance of certain aspects of food preparation, production and presentation (and presumably consumption) played in the ideology. The 'Quern Wall' identified in phase 2 of the Jarma excavations may further indicate the continued significance of some elements of food preparation in the later period at the site. In addition, the role of imported artefacts associated with food, and the apparent domestic production of flour and bread, the role of 'luxury foods', beer and/or wine and certain culinary traditions are all aspects which have strong cultural associations and consequently provide some clues concerning social structure and cultural origins of the population (e.g. Palmer 2002; Lyons and D'Andrea 2003; Edwards 1996b).

10.3.1 Identifying Luxury Food and Conspicuous Consumption

The identification of 'luxury foods' can be used as a marker of social stratification but also trade contact and changing social structure. Luxury foods are usually taken as those which are exotic, expensive or difficult to obtain but which are unnecessary in terms of human nutrition (Van der Veen 2003 for discussion on definitions). The most easily recognised 'luxury foods' in this respect would be exotic imports, such as pepper or nutmeg into medieval Britain, grapes into Iron Age Britain, or Mediterranean wine container and glasses in Garamantian graves. Yet even here there are problems in definition. As Van der Veen (2003) points out, for a good to be truly a 'luxury' it needs to be desired by many but obtainable by few. Goods used in funerary rites, religious offerings and other rituals might be regarded as 'instrumental needs' not luxuries, being necessary to placate the gods, honour deities etc (Van der Veen 2003, 407; Berry 1994). Furthermore the luxury element may be the result of complicated culinary preparation of quite ordinary produce or the presentation of those ingredients (Waines 2003). In societies without strong social stratification feasting and excess are often more significant than exotic ingredients, while in more hierarchical societies the emphasis might be on quality or style (De Garine 1976; Goody 1982; Van der Veen 2003). The identification of luxury goods then can assist with our interpretation of social structure but is multi-layered and complex.

For the purposes of this study the definition of 'luxury goods' used will be those that are exotic, expensive, difficult to obtain or difficult to cultivate. The presence of imported artefacts associated with wine consumption has already been referred to. Wine is regarded as being associated with the elite in Pharonic Egypt (Murray 1999) and in Nubia (Edwards 1996b). Conversely by the Hellenistic period in Egypt it is likely that the consumption of wine became more widespread with the influx of a large Greek population and their cultural preferences as well as technological innovations in terms in irrigation (Murray 1999). The presence of wine amphorae is fairly widespread in Garamantian graves and it is yet to be established if they represent an elite preference or if it was more widespread. Certainly the presence of amphorae and associated drinking and eating vessels including glass ware, indicate successful trade relations and some degree of wealth.

Exotic food plants identified in archaeobotanical samples are those which can be regarded as foreign or unusual in the context in which they are found. In this respect even sorghum and pearl millet might be regarded as 'exotic' when they are first recorded. Pearl millet appears to have become a staple fairly rapidly, but the evidence for sorghum is poor until the later medieval period and it could therefore always be regarded as exotic. Equally it could be associated with a presence of sub-Saharan, possibly slave population, cultivating their own 'exotic' but not necessarily 'luxury' crops. It is probable that the cultivation of the summer crops (pearl millet, sorghum and cotton) was associated with the introduction of the *foggara*. It is not possible at this stage to determine if the *foggara* facilitated the widespread cultivation of crops which were already in limited cultivation or if the *foggara* came first and these new crops followed. Which ever came first the cultivation of new crops, if by wheat and barley farmers, does imply some degree of cost, either in their own or in other labour (including slaves). It is possible that only an elite member of society would have access to the labour facilities to invest in new crops or in new irrigation technology. The concept of early domesticates and the process of domestication being associated with luxury foods and prestige goods has been argued by Hayden (1990; 2003), Stahl (2003) and Lewthwaite (1986). The date stones recovered from pastoral period burials in Wādī Tanezzuft (Cottini and Rottoli 2002, 174, 179, footnote 19) must surely be seen as prestige goods despite dates being a staple food by the 1st millennium BC. It is worth noting here that the tradition of giving food offerings and the emergence of burial traditions reflecting increased social hierarchy occur at a broadly similar period (di Lernia et al 2001; di Lernia and Manzi 2002).

Always rare in the deposits are certain fruits which would have been particularly difficult to cultivate successfully in the Fazzān. Grape and fig appear to have been cultivated fairly successfully given their ubiquity in the samples in all phases, and therefore should perhaps not been seen in this category. Rarer fruits which perhaps should be regarded as 'luxury' foods were the olive (phases 5 and 6-7), pomegranate (phases 6-7, 6 and 5), almond (phases 5 and 6), and peach (phase 1). There are ethnographic accounts of the cultivation of pomegranate, almond and peach in the region in the 19th century, although Nachtigal suggests it is only the wealthy who attempt to cultivate them (1897, 117) and Lyon states that pomegranates are fine but not plentiful while peach never comes to maturity (Lyon 1966). All three could have been imported from Tripolitania where they are known in Roman period deposits (Van der Veen, Grant and Barker 1996). Similarly the olive may have been cultivated locally with great difficulty. Indeed there were rumours of a tree when Nachtigal was travelling in the region (1897, 117). As discussed in chapter 5 the presence of olive stones would indicate the presence and consumption of the fruits. Fruits may therefore have been imported from Tripolitania as well as the oil.

Whether these fruits were imported or cultivated locally they still are suggestive of luxury to some extent. Local cultivation would be extremely difficult and labour/water intensive, therefore suggesting available time or labour for these exotics in addition to the provision of staple foods. The historical references to their cultivation by the wealthy in the 19th century further support this interpretation and confirm the notion of 'luxury' foods in association with social hierarchies. The fact that they tend to be restricted to the Garamantian period would suggest their importation or cultivation was related to the wider adoption of apparently high status Roman products, although this may simply be a product of preservation. The paucity of these products in the deposits generally would seem to suggest they were rarely consumed therefore supporting the notion of 'luxury'. While some 'luxury' foods can therefore be identified there is not evidence to suggest the level of consumption of expensive food stuffs was ever significant even during periods of economic success. The rare occurrence of luxury foods in addition to the burial evidence would support the interpretation of a social hierarchy and personal ambition to obtain goods associated with the elite, which is most evident during the Classic Garamantian period. The actual extent of personal wealth or control of resources or other members of society is difficult to establish and may never have been extreme given the limitations of the environment.

10.3.2 Daily Staples: The Evidence for Flour and Bread Production

The evidence for flour and bread production derives from the quern stones and mortars and physical evidence for bread baking technology (ovens and *dokas*). Ethnographic observation also raises possible hypotheses. Flour and bread are daily staples, the methods of production of which are closely associated with cultural traditions as well as the organisation of society.

As discussed in chapter 8 the stone artefacts, particularly quern stones, appear to have had a particularly significant role in the society of the Wādī al-Ajāl. Quern stones are found in Garamantian period burial contexts, while quern stones and mortars form a significant component of a wall in Phase 2. While the precise details of the ideology behind quern stone placement in burial contexts cannot be unravelled, they surely indicate an emphasis on flour production and presumably grain but also the value afforded to grinding equipment. There also appears to be a personal, domestic element involved, the querns presumably representing personal possessions. The recovery of querns and mortars in domestic contexts throughout the period of occupation at Jarma indicates that flour production was a domestic task. It has been suggested on the basis of ethnographic evidence that ownership of quernstones was by women and represents part of package of domestic equipment and as such may be related to household wealth.

The continued importance of small scale grinding equipments (both rotary and saddle querns) indicates that some level of flour production always took place on a domestic level, and has done so until recently. Indeed there is no evidence for any type of local mechanized mill (or other large scale processing equipment such as olive presses) despite extensive survey in the region. Such household production of flour and bread rather than communal production may be related to increased economic and social divisions. Halstead (1995) has linked a shift from communal cooking facilities to compound and then household based facilities during the Neolithic to early Bronze Age transition in the Aegean, to increased economic and social inequality and a decline in reciprocity amongst socio-economically dependent groups. Samuel (1999) argues similarly that increased centralised state provision of resources, including grain and bread, resulted in households of similar socio-economic status (workers) showing increased individuality of organization of resources. Individual ownership of quern stones and production of bread in a pre-monetarised state may then be related to increased social hierarchy and economic division, also reflected in the range of types and qualities of grinding and food preparation equipment. The relationship between grain use, wealth, household size and social structure and quern type is an interesting one which will hopefully be explored with further field work in this region and others in North Africa. In the case of Jarma the quern stones appear to indicate some degree of social stratification and domestic focus in terms of food production which remained constant throughout the period of occupation at the site.

Bread production appears to have been on a similar domestic scale in the region until very recently. The evidence for the nature of bread production relies on *dokas* and tanur type bread ovens as well as ethnographic observation. Bread ovens appear archaeologically to have been a late introduction, possible associated with Arab populations. Bread baked on ceramic *dokas* or in the ground may well have been the staples prior to the arrival of ovens. This in turn may be related to grain types or mobility. It has been argued that the predominance of griddle breads in parts of Africa is related to the traditional use of starchy grains such as millets for bread (Lyons and D'Andrea 2003) which are better suited to pancake type breads than oven breads. It is also possible that the absence of ovens and predominance of flat batter breads is related to the highly mobile character of Saharan society, particularly prior to the establishment of settlements on the promontories such as Zinkekra in the late 2nd millennium BC and the introduction of agriculture. The widespread tradition of baking bread directly in the sand, recorded across northern African and the Near East is likely to be related to mobility and is undoubtedly ancient. The introduction of *doka* ceramic types may be related to the introduction of sorghum and/or pearl millet cultivation and bread, possibly representing the same traditions as seen in the Middle Nile Valley. The fact that the *doka* appear to be used differently to those in the Middle Nile Valley, not showing evidence of use directly over fires, may indicate that they were adopted as an exotic curiosity rather than arriving with *doka* using communities.

10.3.3 The Role of Beer and Wine in Garamantian Society

As discussed in the previous chapter, beer, particularly sorghum beer, plays a significant role in many sub-Saharan societies. The recognition of beer production and use in the archaeological record without sediment or residue analysis is problematic. The presence of large jars, such as those found in Meroitic and post-Meroitic assemblages in the Middle Nile Valley may provide some clues. Ethnographic evidence suggests large jars have a strong association with production and consumption of beer, for example among the Gamo in South-Western Ethiopia who use jars which are on average 33.6 litres in volume (Arthur 2003, 522). Beer is central to feasts which involve abundance and consumption of large quantities, therefore leaving some signature in the archaeological record (Arthur 2003, 522).

Archaeological and archaeobotanical evidence suggests that in the Middle Nile Valley (Nubia) there is a long history of wild grass utilisation, and possibly cultivation, including of wild *Sorghum* and *Pennisetum* before the introduction of domestic crops (Magid 1989; Haaland 1987; Dirar 1993). Dirar suggests that both the botanical diversity of sorghum varieties in the region and the exceptional diversity of sorghum-based foodstuffs in today's society provide evidence for a long history of its use (Dirar

1993, referred to in Edwards 1996b). Fermented alcoholic beers (*merissa*) and unmalted porridges based on fermented dough are prominent among those foods (Edwards 1996b). The Kushite (c 700- 400BC) ceramic repertoire includes a range of simple cooking jars and bowls and larger, probably liquid containers. A long necked globular jar was interpreted as associated with beer due to its similarity with beer-jars in use in Sudan in the early 20th century (Crowfoot 1925). The large jars become particularly prominent in Meroitic (c.300 BC-AD 350) and post-Meroitic assemblages. A decline in liquid containers is visible in the assemblages of the Christian period (Adams 1986). As the jars appear before ceramic *doka* (which appear in the mid-first millennium AD), it has been suggested that grain was previously consumed in non-bread forms, including beer (Edwards 1996b). Edwards therefore suggests that beer consumption may have a long history in the Middle Nile Basin which may have been particularly significant in mortuary rites, both in mortuary banquets, but also during the construction of the often substantial tumulus mounds covering burials (Edwards 1996b, 74).

While there is no evidence of large scale beer consumption in the form of large deposits of beer vessels, several jars have been recovered from excavation and survey in the Fazzān many of which are likely to have contained liquid or semi-liquid foods including beer. For example, a large, deep jar, type 321, appears to be of later 1st millennium BC to c. 4th century AD (Leone *forth.*), occurring at a similar time ot the first evidence for sorghum and pearl millet. It is possible therefore that there is an association with some forms of jar, and possibly beer, with the introduction of sorghum which might suggest sorghum was introduced into the Fazzān as a beer crop. However there is no evidence of mass consumption of beer or of its significance being comparable to that in the Middle Nile Valley (Edwards 1996b).

The role of wine in the Fazzān, particularly in the Garamantian period is much more in evidence archaeologically. Grave goods in the Classic Garamantian period typically include wine amphorae and drinking vessels including jugs, cups and glass beakers (Fontana 1995; Mattingly and Edwards 2003). Other imported goods include jewellery (both local and imported), pottery including Italian *sigillata* and oil lamps, while more locally made jewellery, head rests, ceramic incense burners, mats and leather shrouds are also recorded (Mattingly and Edwards 2003). Wine and drinking appear to be of sufficient importance that great care was taken to import fragile glass vessels from the north coast. There appears therefore to be an emphasis on expensive imported product (as opposed to quantity) and presumably some notion of social elitism.

The use of imported wine is also seen in the Middle Nile Valley from at least the first millennium BC, possibly earlier, the wine being imported from Egypt. Amphorae, texts and reliefs give testament to the importation of wine into Lower Nubia from Egypt throughout much of the Pharonic period. Adams believes the Egyptian colonists of the New Kingdom (1550-1070 BC) brought the habit and the wine with them (Adams 1966) and wine imports appear to have been imported with occasional interruptions until well after the Muslim conquest of Egypt. The Meroitic period (c.300 BC-AD 350) appears to have been one of mass importation, attested by the thousands of imported amphora fragments found on Meroitic sites (Adams 1966). There also appear to have been episodes of wine production in Nubia, although generally short lived (Vercoutter 1959; Adams 1966; Meeks 1993). There were apparently attempts at wine production under the rule of Taharqa in the 6th century BC (Macadam 1949), despite open trade links with Egypt at that time, and again at the close of the Meroitic period when there was an interruption of trade with Egypt (Adams 1966). This later episode of wine production is suggested by possible wine presses in Lower Nubia (Adams 1966) and grape vine charcoal found at Arminna (McWeeney, quoted in Fuller 1999).

Clearly, imported wine and associated goods were of some importance in the Fazzān during the Classic Garamantian period. This is the period of most visible trade with the Roman province to the north and of conspicuous wealth in the region. Of course the presence of goods in a mortuary context does not necessarily indicate use in life, but it does indicate some symbolic significance. The fact that the vessels of consumption are present might indicate consumption of goods as part of the funerary rite itself or might simply be offerings to the gods or intended for the deceased in the after life. The adoption of foreign alcoholic beverages, particularly by elite groups, is a common pattern and often involves its assimilation into elite culture including religious rites (Dietler 1990; Sherratt 1986). Edwards therefore suggests that in the Middle Nile wine is an elite adoption which extends and amplifies more widespread indigenous practices which could involve beer (Edwards 1996b). A similar practice in the Fazzān is entirely plausible where certain aspects of Roman material culture appear to have been adopted into existing indigenous practices. The adoption of beer or particular types of beer such as sorghum beer may be interpreted in a similar way.

10.4 Trade of Consumables: an Agent for the Diffusion of Crops

Sherratt (1999) has suggested that trade in consumables is one way in which crops, particularly non-staple crops, spread beyond their core areas of domestication. A crop in which this might be argued for the Fazzān is cotton, although this does not imply it was then cultivated in the Fazzān for trade purposes itself. Cotton cloth was widely traded during the Roman period, particularly into Egypt, much of which derived from India: the *Periplus Maris Erythraei*, a 1st century AD text from Alexandria records the importation of Indian cotton (Casson 1989) while the *P. Vindob* G. 40.822, a mid 2nd century papyrus, lists cotton cloth amongst a luxury cargo sent from India to Egypt and onto Alexandria (Harrauer & Sijpesteijn 1985; Thür 1987; Casson 1990; Sidebotham 1991; Wild 1997). There are also references to cotton textiles from the Gulf region suggesting its trade across the Indian Ocean, (Wild 1997, 293), although Bahrain may also have been a significant producer. The presence of large quantities of fragments of cotton cloth were reported from the Red Sea port of Berenike, the quality, spin direction (S- and Z-spun) and weave technique of which have led Wild to suggest more than one source, possibly including Nubia (Wild 1997). The great demand for cotton cloth in Egypt then presumably led to more locally produced cloth entering the markets. Recently radio-carbon dates have been obtained on cotton seeds from Qasr Ibrim indicating it was present in northern Nubia by the first or early 2nd century AD (Clapham *pers comm.*). It is recorded at Kellis, Dakhla Oasis at least by the 4th century AD (Thanheiser 1999; Bagnall 1997) and at North Kharga Oasis possibly at a similar date (Clapham & Dorri *unpubl.*). It had reached Jarma by cal AD 140-380 (2nd to 4th century). It is possible therefore to envisage a westward spread of a desirable product at a time when a number of factors must have been in place, including demand (which may simply be fashion led), irrigation technology and labour. If the centre of demand was the Egyptian Nile Valley, the cultivation of cotton within the oases may have evolved to fuel that demand, while contact with societies further away from that initial centre eventually led to demand in those regions, including the Fazzān, and subsequently local cultivation.

The adoption of wine and beer into Garamantian culture may be seen as a similar process. In this respect staple grain crops such as pearl millet and sorghum may have entered Garamantian awareness through trade relations with Sahelian peoples, perhaps in turn being closely associated with beer or certain bread types and therefore resulting in the introduction of particular ceramic forms. Date should also be considered as an item initially introduced to areas beyond its range of domestication by trade. The use of dates in pastoralist burial rites in the 2nd millennium BC (Cottini and Rottoli 2002, 174, 179, footnote 19) perhaps indicates its significance to pastoralists living on the edge of the sphere of agriculturalists. Wine and beer may be similarly regarded, both perhaps initially being adopted be a social elite, later resulting in the cultivation of grape and sorghum.

The unique geographical situation of the Wādī al-Ajāl and the command the local population must have had over their surrounding areas and also trade through the region must have afforded them access to a range of crop and food types, none of which can be regarded as indigenous but which may have been adopted into their own culture. It has been demonstrated that the cultural archaeology, particularly in terms of burial customs, tomb types and burial assemblages, represents a fusion of both indigenous and imported traditions (Mattingly and Edwards 2003). It is suggested therefore that the position that the Garamantes and later populations held in terms of long distance trade and transport routes through their region has resulted in a unique blend of indigenous, Sahelian, Nilotic and Mediterranean traditions which are reflected in agriculture and food as well as other aspects of the culture. In this respect they can be compared to Nubian populations in the Nile Valley who have had a long tradition of both Egyptian and Sahelian trade links which have had a profound affect on their culture.

10.5 Subsistence or Market Economy?

It was an aim of this discussion to present some conclusions concerning the nature of the arable economy at Jarma and in particular if the archaeobotanical and archaeological evidence would indicate the scale and intensity of arable production. The scale and intensity of production is likely to be related to the nature of the economy, that is whether production was essentially subsistence based or whether arable production was somehow related to a market economy. In a subsistence society, cereals and other crops are primarily produced to meet the requirements of the family or immediate community, most of whom are involved in the agricultural process and any surplus serves to provide a buffer for bad years (Bakels 1996). In a market economy, the production of cereal crops is in part the result of demand from elsewhere and surplus is deliberately produced to support non-agrarian members of the community or to obtain goods not locally available (Bakels 1996; Van der Veen 1999). The distinction is potentially important because it relates to the nature of the community, market economies tending to be associated with more complex and stratified societies. In reality, as the present day examples from Jarma and the Fourth Cataract of Sudan demonstrate, the distinction is not clear cut, but one of sliding scales, most 'peasant' farmers producing food for market when sufficient surplus is produced. Further more, there is a complex relationship between pastoralists and agriculturalists as seen between the Tuareg and settled farmers of the Ahaggar which is difficult to detect archaeologically.

The occupants of Old Jarma were clearly involved in trade for manufactured goods, including glass wear and fine pottery, at least during the Garamantian period, and there is ample evidence for the local manufacture of jewellery and copper goods. In this respect a 'market economy' on some scale can be envisaged, although this need be little more than occasional trade beyond subsistence level by a few individuals or for particular events such as burial feasts. The level of local bead or copper manufacture might not have been more than domestic production for personal use. The procurement of significant quantities of goods which must have been assigned a high value (glass ware imported from the Mediterranean for use in burial rites for example) must have required some items of value for reciprocal exchange. Slaves, salt and wild animals have been postulated for such a purpose (Mattingly 2003). What role then did arable products play in the economy of the Garamantes and subsequent periods? Did agriculture merely support those elements of society who were involved in trade, hunting and so on, or were arable products also used for trade?

As discussed above there was a period of increased crop diversity beginning in the later centuries BC which appears to have coincided with increased material wealth and an expansion of arable land as a result of the introduction of the *foggara*. This must therefore be seen as a period of increased intensification and expansion of production.

Once the *foggara* systems collapsed there was a contraction of arable fields around wells which appears to have coincided with a period of decreased population (Mattingly 2003c). It is not, however, possible to state whether increased arable production was driven by the need for more arable products and if so if surplus production resulted in increased trade of food and other consumables, or whether it simply fed the labourers (slaves or otherwise) involved in the construction of *foggara* and other works. As the Tuareg example in the Ahaggar in the 1950s demonstrates, slave ownership and *foggara* use does not necessarily imply a large scale market economy (Nicolaisen and Nicolaisen 1997). Here the pastoral Tuareg garden owners take a percentage of the grain produced by the settled subsistence farmers.

The production of '*normal surplus*' over domestic needs in average years is seen in most 'peasant' farming societies as a way of avoiding shortages in unusual years (Halstead 1989; Forbes 2002), as well as to meet exchange needs for products not produced by a farmer or society. Forbes (2002) further suggests that in unusual years, for example during period of conflict or even perceived threat of conflict, peasant farmers are more likely to hold onto that surplus rather than release it into the markets, even if the end result is reduced value of those goods. Therefore it is in periods of potential conflict or perceived conflict, with possible withdrawal from the markets, that we might see a change in storage and the construction of more substantial storage facilities. In times of economic stability normal storage may be harder to detect. In the Fazzān a period of increased instability is indicated for the late Antique period, or Late Garamantian Phase (3rd to 9th centuries AD), reflected in the appearance of large number of *qsur*, or fortified buildings (Mattingly 2003b, 146-54). Identification of household storage of the non-elite in periods of peace time is much harder to recognise archaeologically, particularly if storage is held in sacks or baskets. Consequently we have no evidence for storage facilities from the Classic Garamantian period in which a perceived production of increased surplus is likely to have occurred, making any assessment of surplus production impossible to quantify. Neither does the density of crop products provide clues as to the scale of production. A dramatic increase in arable production might be reflected by greater quantities of stored crops and increase risk of burning of stored product. However, there is no obvious increase in the density of crop products in the Garamantian period compared to later periods. The earlier phases are poorly represented in terms of plant remains although the samples were largely taken from the temple structure and may not be expected to yield significant deposits of crop plants.

While the introduction of new crops to the Fazzān may be linked to trade there is unfortunately little in the data available to indicate the part in which local arable production contributed to trade activities or the economy in general. There was a period of increased arable activity during the Garamantian period in which increased output is likely to have been achieved through increased diversity, particularly in the introduction of summer crops and the expansion of cultivated land as a result of *foggara* irrigation. Slave labour may have been employed in the construction and maintenance of the *foggara*. Certainly sufficient labour in some form must have been available. The scale of crop processing waste present on the site suggests the local use of a readily available material, although it is perhaps more indicative of the absence of alternatives, such as wood for fuel. Importantly there appears to be a consistency in the pattern of crop-processing by products throughout the period of occupation until the very latest phases at Jarma, suggesting that some basic activities and storage or use of products and by-products remained unchanged. Crop processing waste is best represented in the upper levels where they are preserved by desiccation. This may also represent a period of change in use of this part of the site with a greater emphasis on animal penning or storage of chaff and straw, possibly related to the period of economic decline in the region in the 18th and 19th centuries. It may however, simply reflect change in preservation type and the greater incidence of straw and chaff survival due to desiccation.

As the material wealth of the site apparently diminished the crop repertoire remained essentially unchanged, certainly in terms of the staple crops, although it is possible that by the later medieval period it was no longer considered worthwhile to cultivate grapes or cotton on any significant scale (some limited cultivation of both has continued until at least the 19th century). It is possible that the range of imported goods (for example olive or pomegranate) was reduced in the later period, although this is again difficult to demonstrate. There is similar evidence from the bone data of a decrease in the range of species in the later occupation at the site, which may again be related the later economic decline (Britton and Grant *forth.*).

Both the crop and animal remains therefore suggest a period of arable expansion, possibly intensification and increased species diversity during the height of Garamantian occupation. It is suggested that the adoption of new crops, irrigation methods, as well as new animal species, occurred at a period during which various conditions must have been favourable, including involvement in trade and economic relations, availability of labour and fashion led demands. The increase in grave goods in individual burials would indicate an increase in personal wealth and social hierarchy, which may have resulted in a desire to obtain certain food crops such as olive, fruits, or wine ,and this in turn may have been an agent of introduction of these goods into the greater society. After this period arable production may have remained little changed until perhaps the later medieval period, when the region suffered severe economic decline, although the apparent rapid adoption of maize and chilli/sweet pepper (present from phase 3) suggests that the region was still receptive to new innovations at least in the 15th or 16th centuries. Domestic activities, in terms of crop processing, grain preparation and the use of waste products, may have remained constant regardless of the apparent changes in fortune of the region as a whole. This is also reflected in the bone data which apart from some variation in species diversity, are generally suggestive of subsistence level farming, animals being kept past their prime suggesting they were used for secondary products as well as meat, throughout the period of occupation of Jarma (Britton and Grant, *forth.*). This would therefore suggest that social differentiation may have been reflected in material goods or land ownership but may not have altered the subsistence base of the majority of inhabitants.

While it is difficult to draw many conclusions, there are a number of hypothesis which have been raised from this discussion. The use of plant remains in combination with the archaeological evidence for irrigation (specifically the *foggara*) has suggested a period of intensification and agricultural expansion occurred during the Garamantian period reflected in an increased diversity of crop plants and expansion of ground brought into cultivation. As well as the staple crops this includes so called 'cash crops' and potential 'luxury' foods suggesting a degree of wealth which enabled cultivation beyond subsistence, although these non-staples do not feature particularly significantly suggesting conspicuous consumption of such goods may have been limited. The pattern of waste disposal and use of crop processing by-products as discussed in chapter 6 indicates that despite this apparent period of intensification and expansion of agricultural land, domestic activities may have remained little changed throughout the period of occupation of Jarma, possibly with a change of use of the area of the site excavated in the final phases involving greater storage or deposition of chaff and straw. It has also been suggested that the Garamantian role in extensive trade networks may have been the agent by which new crops reached the Fazzān. The discussion of food as a cultural artefact raises the issue of the complexity of cultural traditions particularly where they relate to food. It is likely that a mixture of both indigenous and imported traditions is represented by the food remains and the accoutrements (both for preparation and consumption) associated with them. The adoption of new crops and particularly 'luxury' goods, including fruits but also perhaps cotton which might be fashion led, should be seen in the context of social hierarchy, these items perhaps becoming more widespread once established.

How crop production and consumption at Jarma compares to other contemporary settlements in the region is yet to be demonstrated. Jarma evolved as an urban or 'proto-urban' settlement during the Garamantian period, while a number of similar larger settlements existed along the Wādī al-Ajāl. Smaller settlements (villages or hamlets) are also spread along the wadi. Through the post-Garamantian period many of these smaller, possibly satellite settlements disappeared as the larger settlements became increasingly nucleated and defensive. It is yet to be seen if the Garamantian period satellite settlements were involved in agriculture to a greater or lesser extent than the occupants of Jarma. It is only when data becomes available from additional sites that the nature of the economy will be explored more fully and satisfactorily. As yet the archaeobotanical remains are consistent with localised production which may be essentially subsistence based, but in which some surplus is produced to enable trade and exchange, possibly with some elite control over production or increased production. The archaeobotanical remains themselves do not provide clues about any centralised organisation of production or construction of irrigation systems. Liverani has suggested that the Saharan environment of the Garamantes would never have supported a rich lifestyle based on conspicuous consumption (2000a). While this may be true in that 'luxury' foodstuffs may have always been limited, the very fact that the Garamantian period involved the adoption of crops from diverse regions including the Nile, the Sahel regions to the south and the Mediterranean, may be suggestive of luxury. Conspicuous consumption to reflect wealth or power may have involved quantity rather than quality or may have involved initially rare crops which later became staples, or may have been based largely on imported foodstuffs and/ or eating and drinking vessels.

10.6 Concluding Remarks

Mario Liverani has suggested that we should view the Garamantes in terms of both the '*longue duree*' and 'wide horizons' (Liverani 2000a). In doing so, the Garamantes can be seen as a civilization which evolved, and for several centuries flourished, through their largely successful attempts at adaptation to major environmental changes. The post-Garamantian period should be seen as part of the same temporal and spatial evolutionary sequence. This thesis has explored the plant remains and agricultural history of the Garamantes and their successors in similar terms, examining both the long term patterns and taking a Saharan wide perspective. It is perhaps only in doing so that it is possible to appreciate the level of success of the Garamantian period agriculturalists. What might be regarded as subsistence level intensive multi-cropping of a range of winter and summer crops can be seen as a remarkable development of experimental intensive agriculture involving newly adopted crops from the fringes of the Sahara when placed in a longer and wider perspective. The new data generated by the thesis also demonstrate the need to re-assess the notion of Watson's Islamic 'Agricultural Revolution' (Watson 1983).

Our knowledge of Saharan agricultural history is poorly supported in terms of archaeobotanical remains. The archaeobotanical data generated by excavations at Jarma, in conjunction with those from its predecessor, Zinkekra (Van der Veen 1992a), have provided an important opportunity to study the history of crop plants from a Saharan oasis over a period of almost three millennia from the early 1st millennium BC until the early 19th century. The weed data generated have enabled some suggestions concerning arable conditions, but more importantly provides a dataset on which to build in the future. The data as a whole have provided some important clues as to the relationship between the people of the northern Fazzān and those surrounding the Sahara, but as yet provides only limited clues as to the relationship between settlements within the Wādī al-Ajāl. Future excavations in the area will hopefully generate more data with which to understand these internal relationships in terms of the production, distribution and use of agricultural products. In addition, there is a need for greater detail from modern ecological studies of weed floras in the Sahara, particularly in regions where farming is still conducted by traditional methods. This is particularly so for the understanding of the impact of different irrigation methods and long term intensive manuring.

The crop species identified from Jarma include several which are included in Watson's 'agricultural revolution' which he places in the early Islamic period (Watson 1983).

> "One important change was the opening of a virtually new agricultural season. In the lands of the Middle East and the Mediterranean the traditional growing season had always been winter ... the summer season was to all intents and purposes dead. Since, however, many of the new crops originated in the tropical regions ... they could be grown only in conditions of great heat. In particular ... cotton ... and sorghum were summer crops in the Islamic world.... The introduction of such summer crops on a wide scale radically altered the rhythm of the agricultural year as land and labour which had previously lain idle were made productive."

(Watson 1983, 123)

Crops identified at Jarma which are included in Watson's list include sorghum (*Sorghum bicolor*), cotton (*Gossypium* sp.), durum wheat (*Triticum durum*), to which should also be added pearl millet (*Pennisetum glaucum*) and possible sesame (*Sesamum indicum*). The Jarma data provide an important comparison with the remarkable data recovered from Qasr Ibrim where these taxa were also recovered at a similar time (Rowley-Conxy1989; 1991; Clapham and Rowley-Conwy *forth*). At both these sites, the 'revolution' of the arrival of these crops can be dated to pre-Islamic times, and is in fact broadly similar, in the late 1st millennium BC and first 500 years AD. In both instances the arrival of the new crops is associated with periods of flourishing wealth, conspicuous consumption and perhaps most significantly periods of global economic expansion with Phoenician and Hellenistic, then Roman expansion in the Mediterranean regions and the emergence of sub-Saharan African city states such as Jenné-Jeno and later the Ghanaian Empire of Soninke, and Aksum in Ethiopia. This period also saw the adoption of the *foggara* or *qanat* irrigation in the Saharan and the Egyptian oasis (Wilson and Mattingly 2003; Wuttmann *et al.* 2000), and the spread southwards of the animal powered *saqiya* waterwheel into Nubia (Trigger

1965; Adams 1977; Edwards 2004), possibly present at Qasr Ibrim by the Meroitic period (Rowley-Conwy 1989). The spread of the dromedary camel into the Sahara is also attributed to this period (Clutton-Brock 1993) and is indeed recorded amongst the bone assemblage at Jarma from the 1^{st}-2^{nd} century AD (Britton and Grant *forth.*). This must then be regarded as a period of remarkable exchange of goods and ideas across the Sahara which should be seen on a broad scale involving both the Mediterranean and African worlds. Importantly, it demonstrates that now as more archaeobotanical data have become available the 'agricultural revolution' that Watson describes should no longer be regarded as Islamic in origin.

It is difficult to establish the significance of these new crops in the economy of Jarma and the wider Fazzān, particularly of sorghum which is always elusive in the archaeobotanical record and represented by only a few grains. The very presence of the crops at the site during this period is of some significance however, and demonstrates the extent of the exchange of ideas and diffusion of crops as well as technology at this period. Liverani (2000a) has suggested that Garamantian involvement in trans-Saharan trade networks was in part an economic adaptation and enabled the development of urban centres and a period of aspirations towards conspicuous consumption. He further suggests that the harsh environment did not allow the concentration of wealth beyond subsistence levels. These conflicting themes are perhaps born out by the archaeobotany. The potential for trade as a means of early diffusion of sub-Saharan summer crops such as sorghum and cotton has been raised (after Sherratt 1999), while other 'luxury' goods such as pomegranate and olives may have been imported from the Mediterranean along with fine glass ware, ceramics, olive oil and wine (and date beyond the Fazzān). This involvement in such wide ranging trade networks, as well as the extent of the *foggara* in the Wādī al-Ajāl, suggests a period of agricultural innovation and expansion. The involvement in trade networks should be regarded both as a means to acquire objects not locally available, but also an adaptive strategy to the increasingly harsh climate and the difficulties in supporting large populations on agriculture alone. The composition of the botanical samples analysed conversely suggests that basic crop processing activities and domestic consumption remained fairly constant throughout the period of occupation at Jarma. This is also suggested by the bone evidence which is in keeping with subsistence level husbandry methods (Britton and Grant *forth.*). It will only be through further excavation and analysis of data that the nature of consumption and crop processing activities will become clearer.

Finally, the creation of a database of North African archaeobotany, and the attempt to apply statistical techniques, has raised the potential for new, integrated methods of analysis of the pan-regional data. The temporal and spatial gaps in the data are a significant limiting factor and the political climate of much of Northern Africa such as north western Sudan, is such that future excavation and sampling in key areas will be greatly hindered. It is hoped that targeted research in the future will include further examination of historical period sites which can add greatly to our understanding of the history of some of the later crops discussed as well as the dynamics of oasis farming and evolving urban or proto-urban sites.

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AGRICULTURE AND TRADE AMONGST THE GARAMANTES AND THE FEZZANESE: 3000 YEARS OF ARCHAEOBOTANICAL DATA FROM THE SAHARA AND ITS MARGINS

by

Ruth Elizabeth Pelling

Thesis submitted in fulfilment of the requirement for the degree of Ph.D. in the Institute of Archaeology, University College, London, 2007

Volume 2: Figures and Appendices

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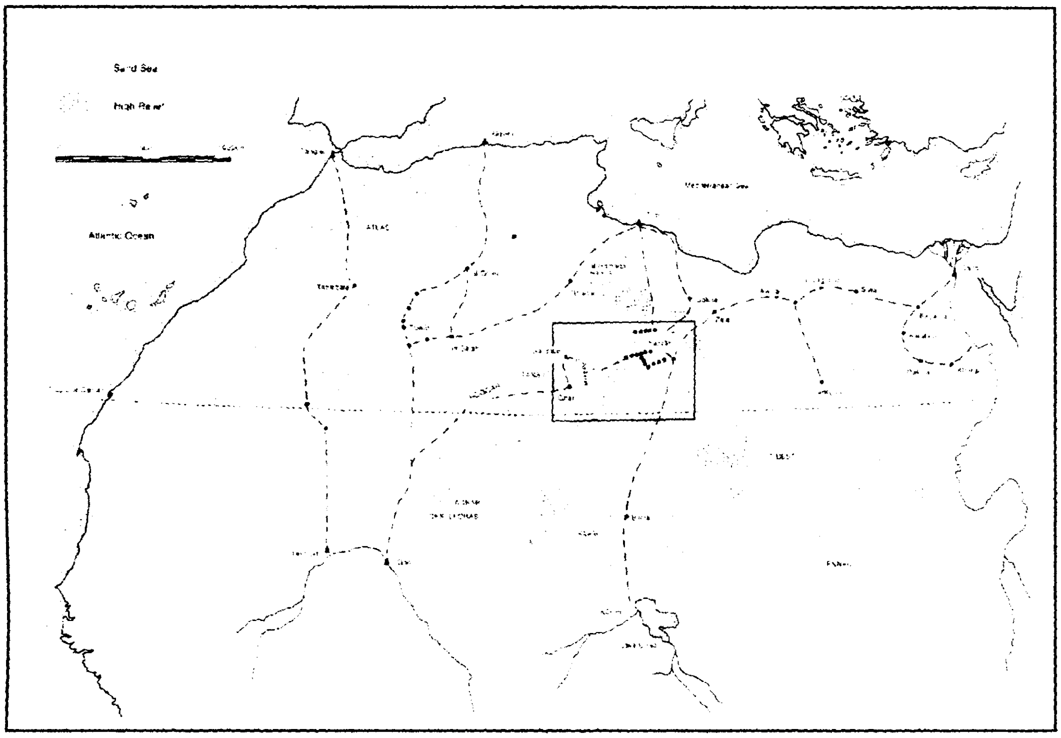

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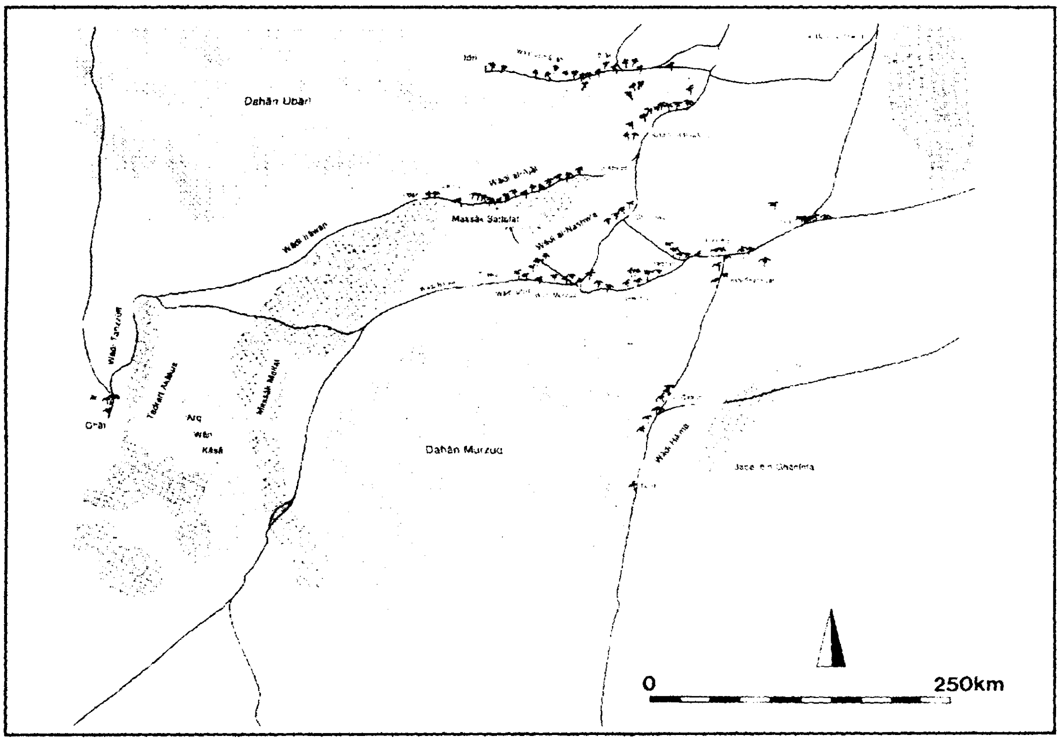

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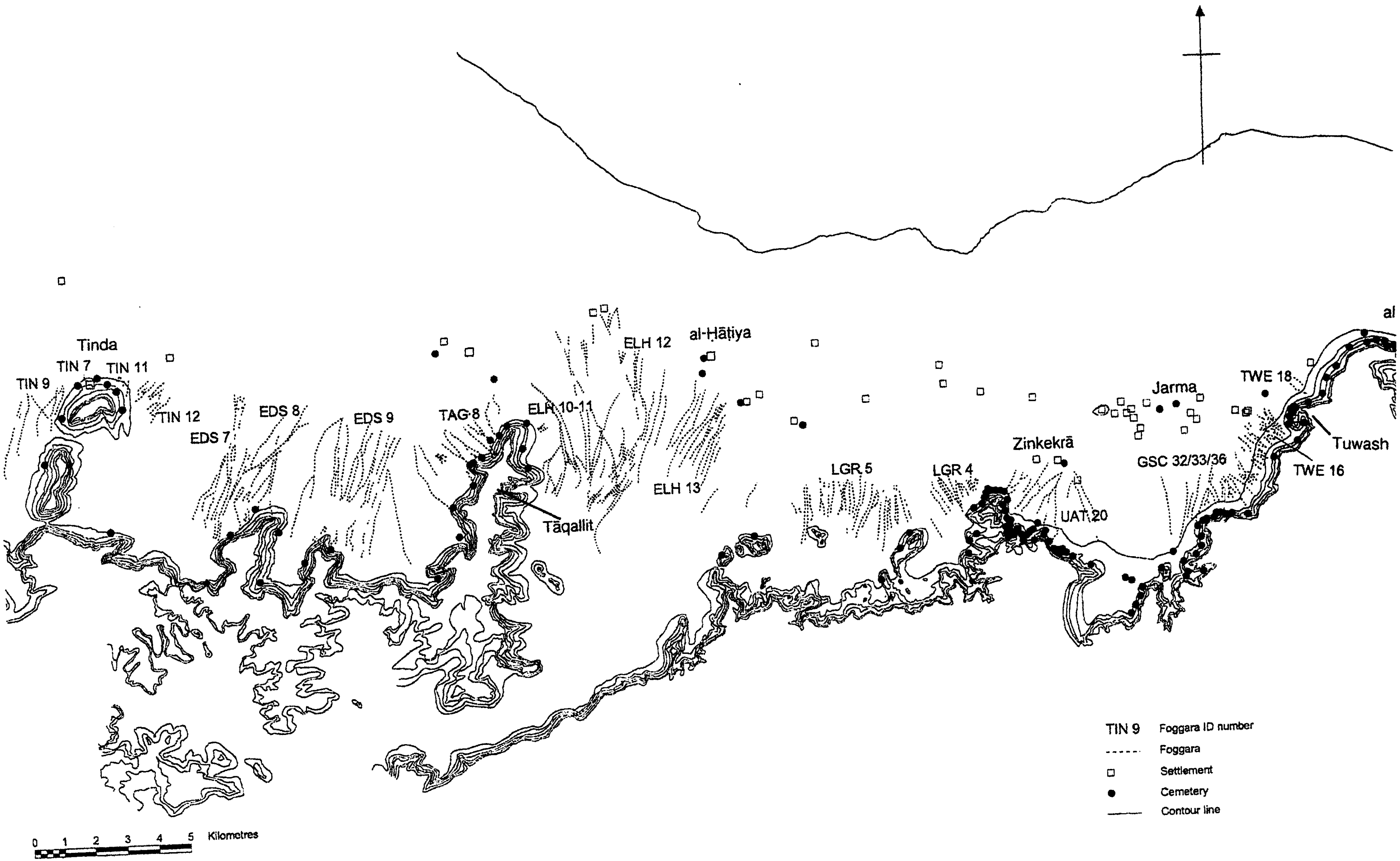

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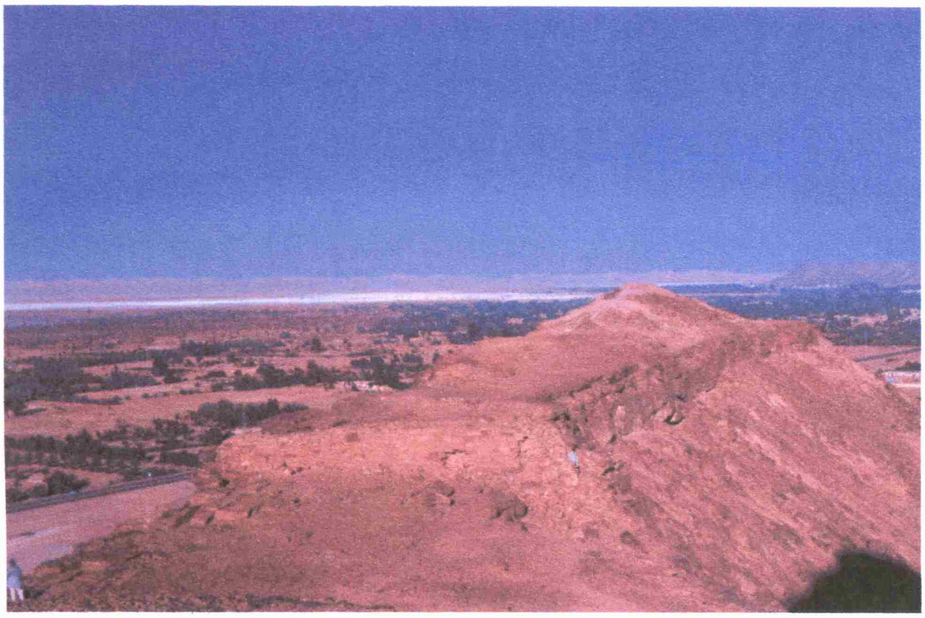

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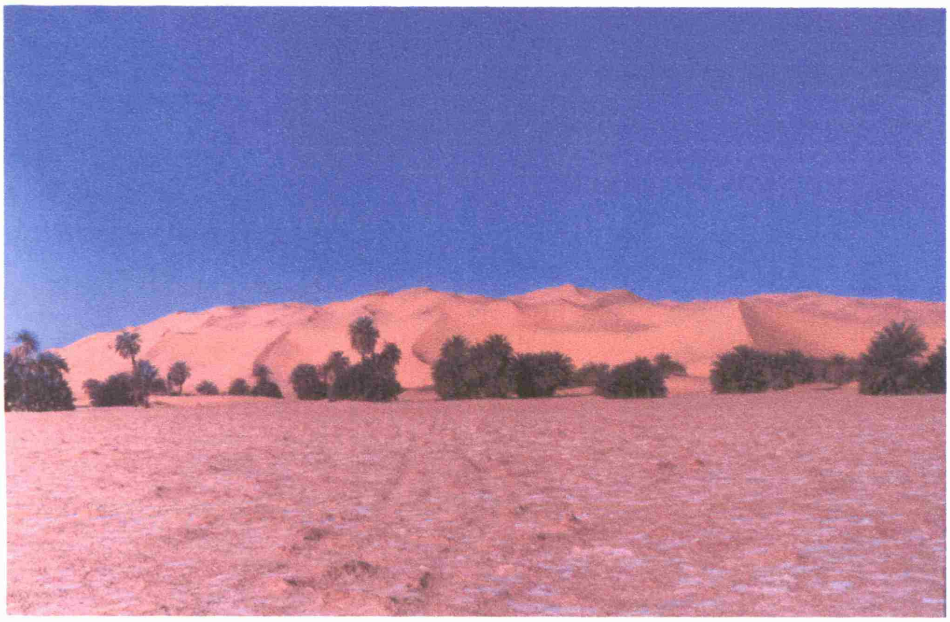

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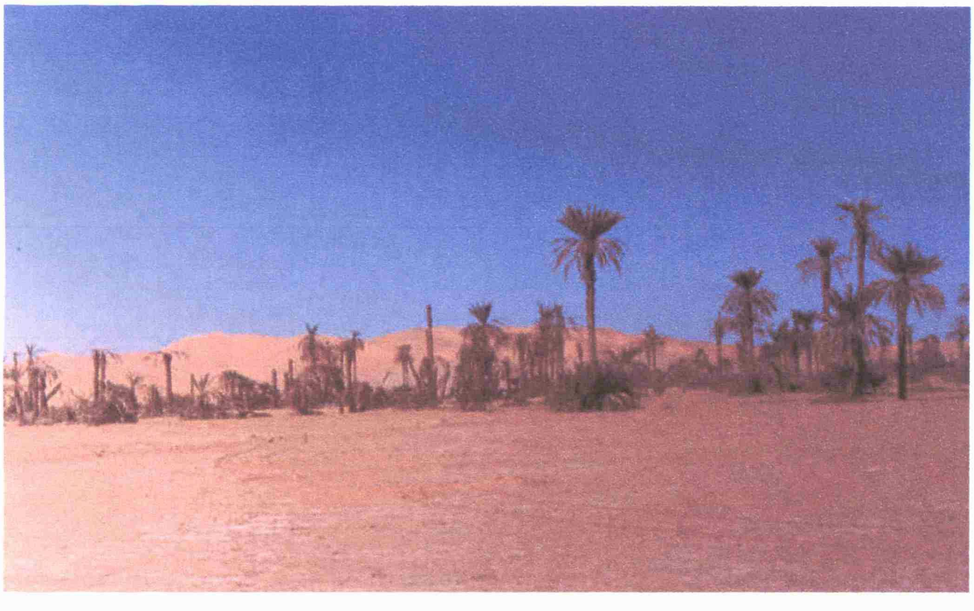

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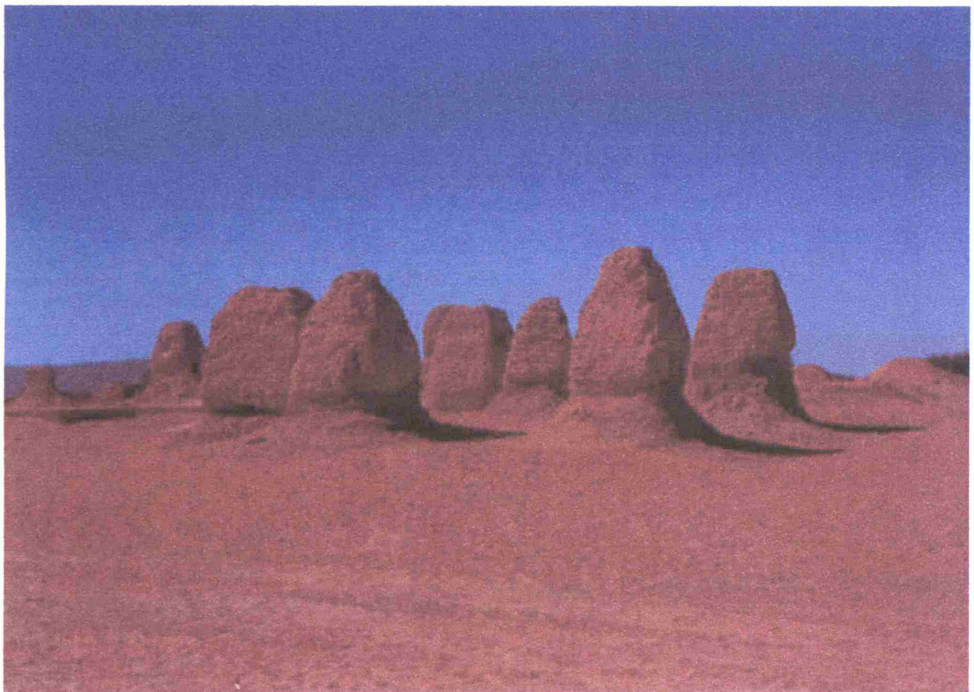

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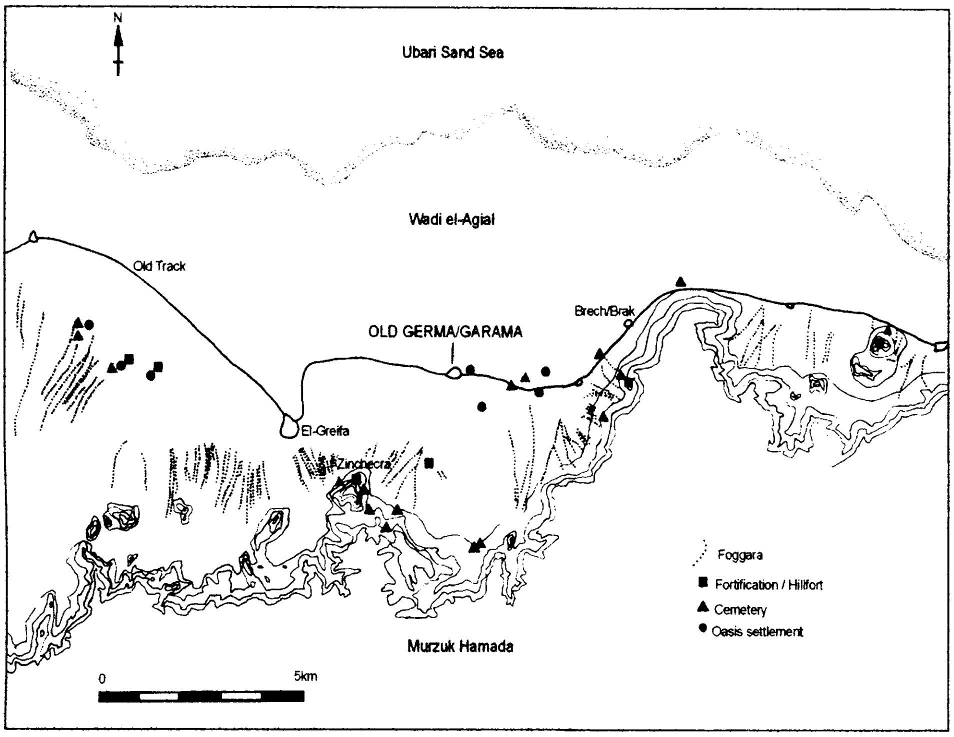

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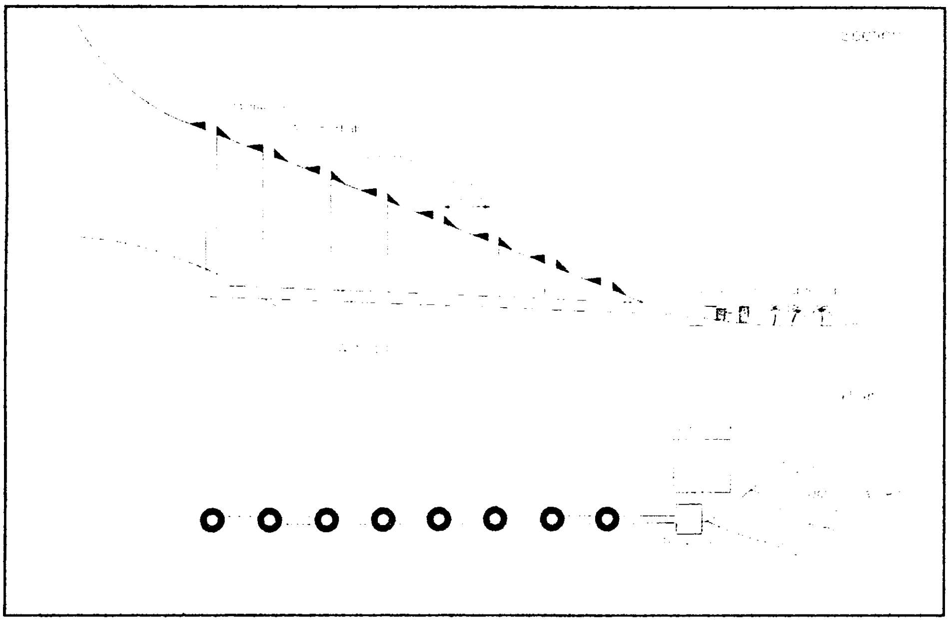

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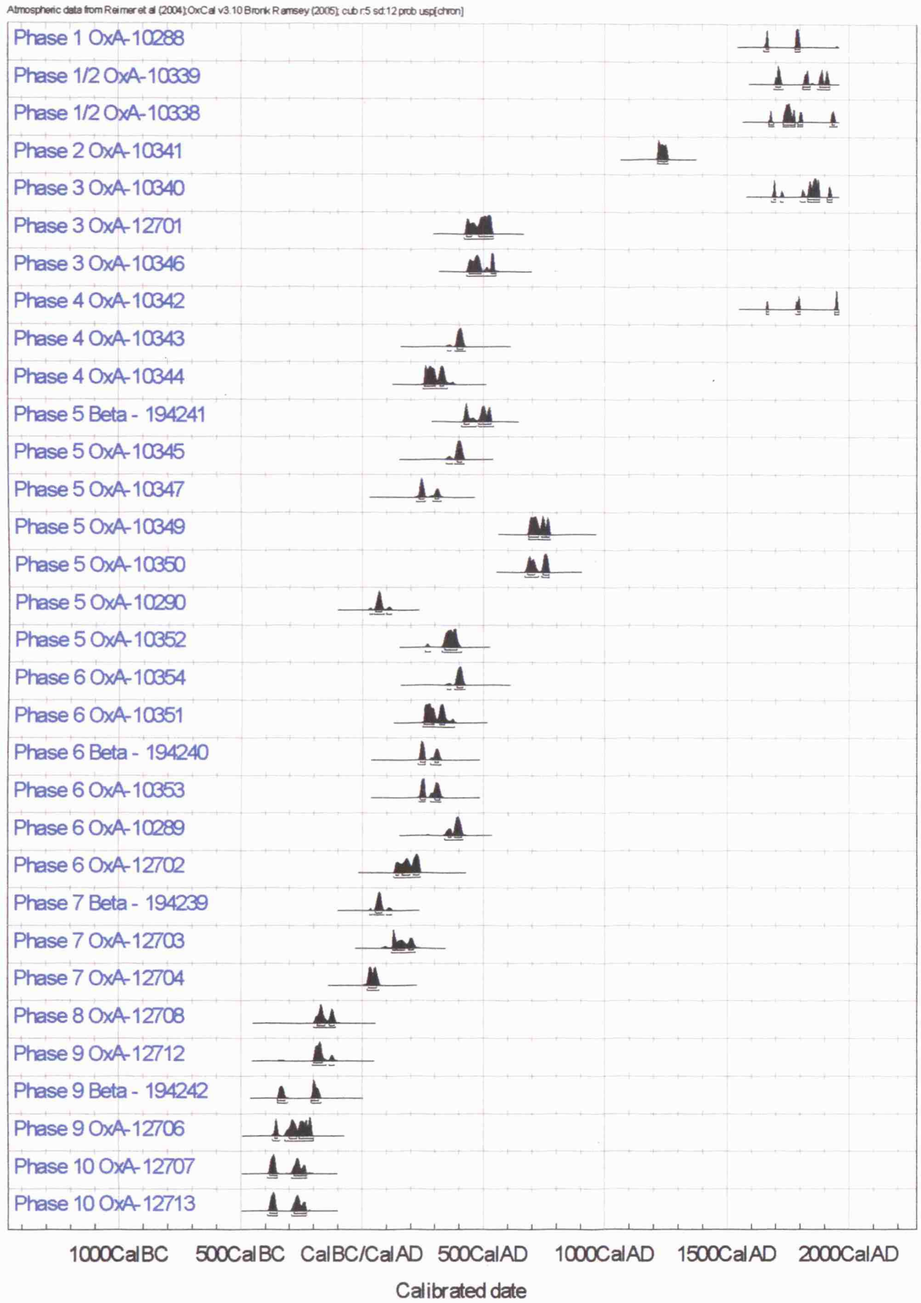

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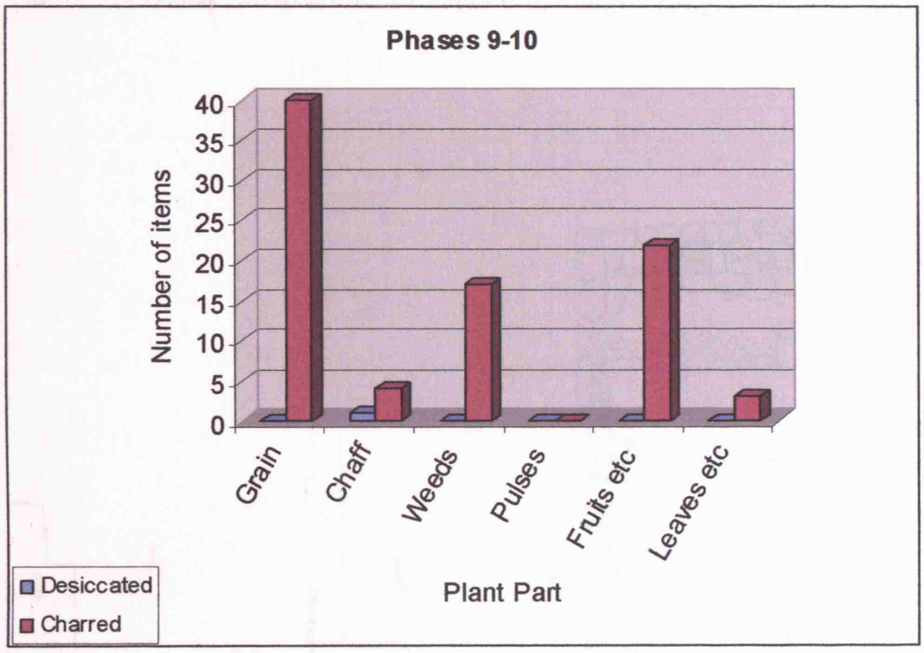

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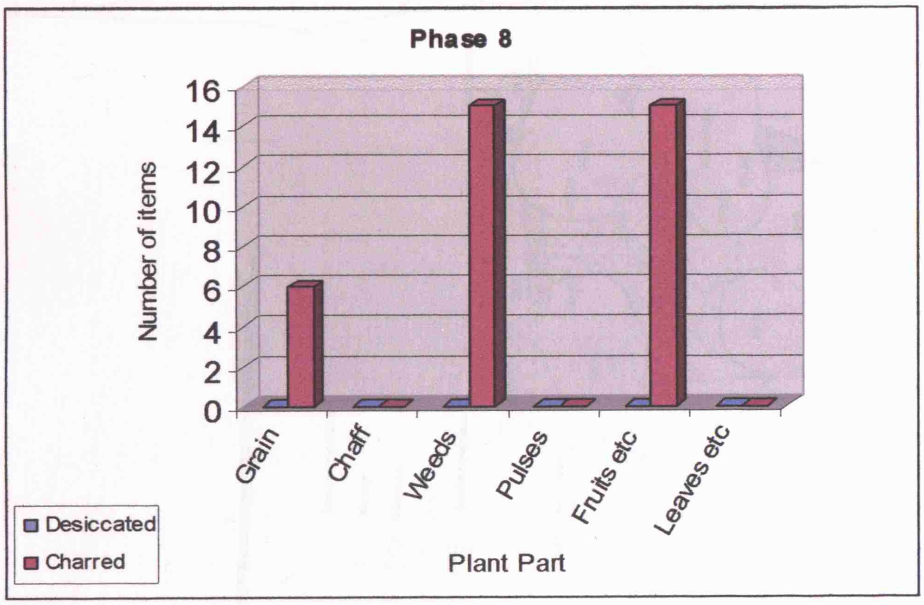

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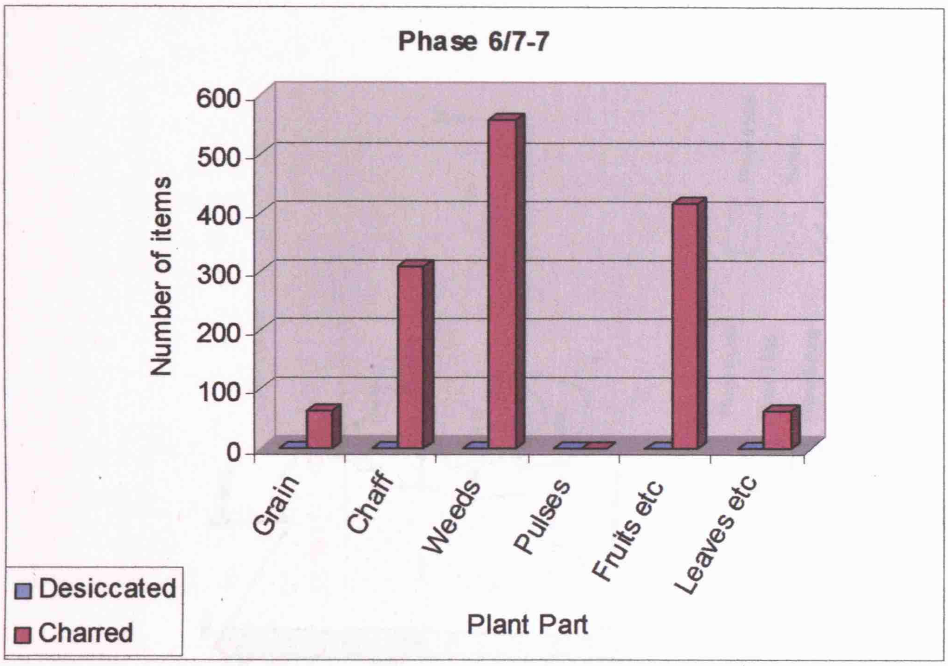

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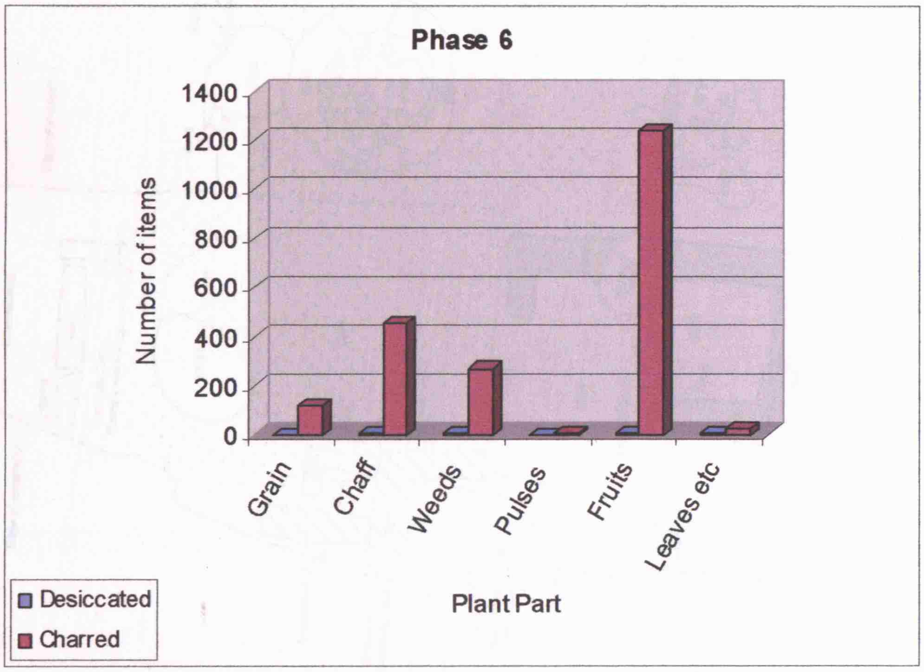

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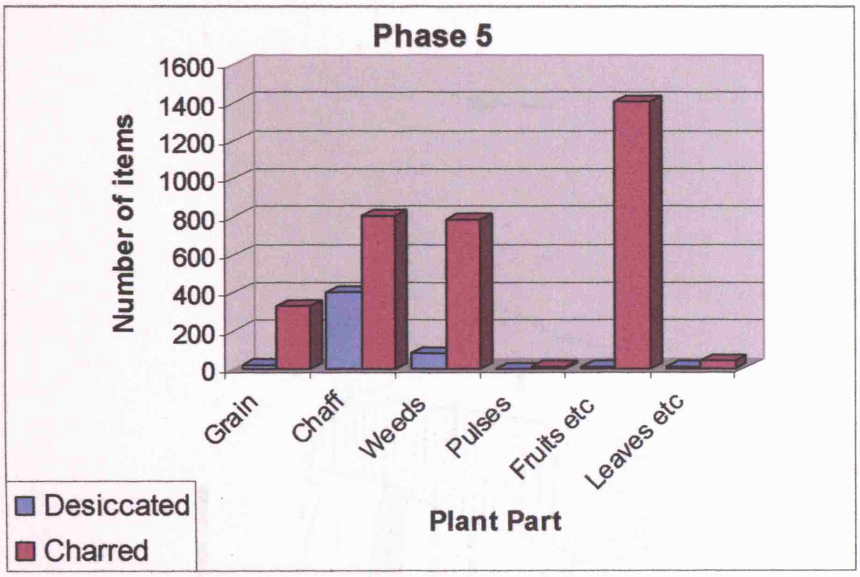

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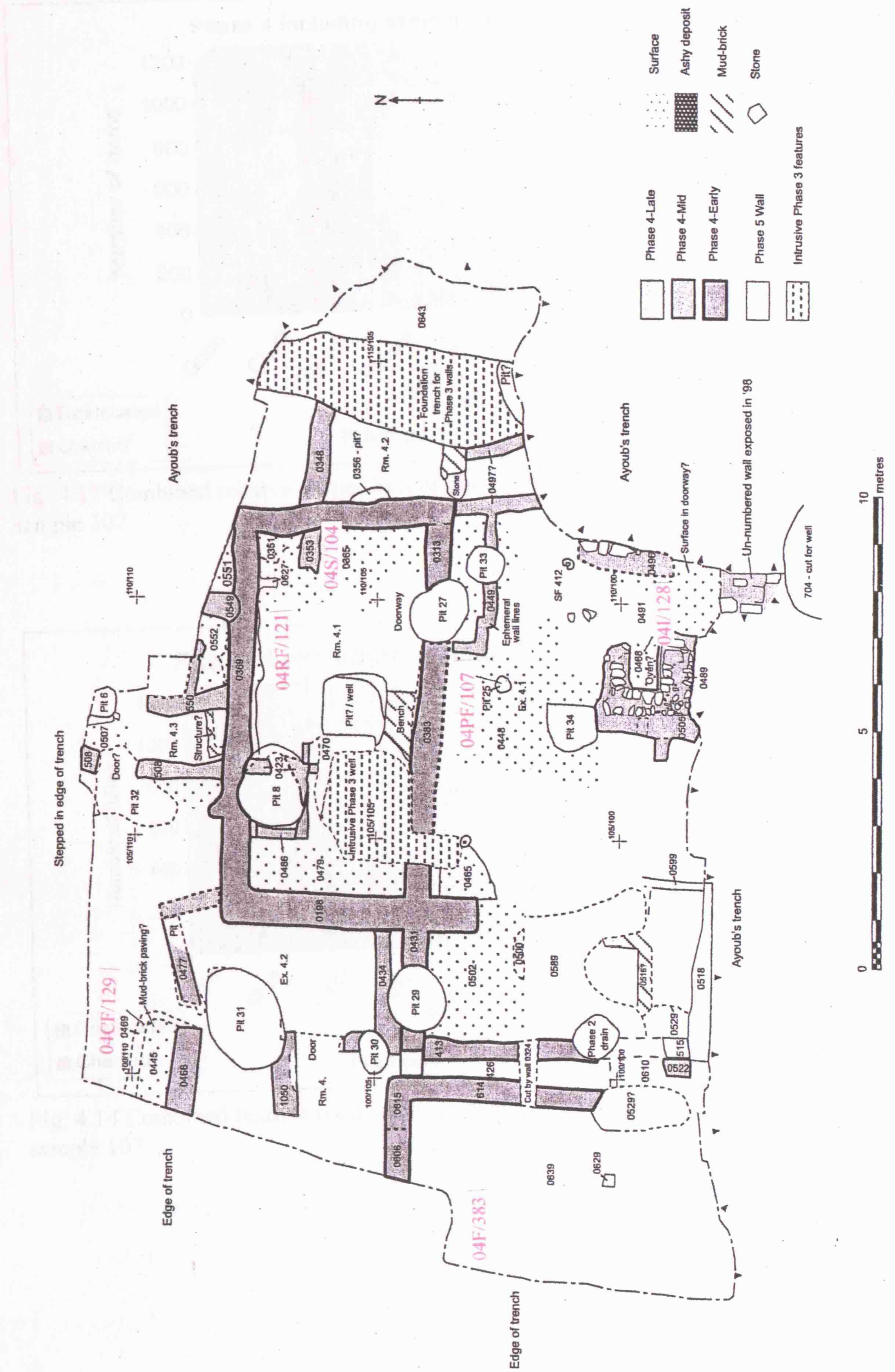

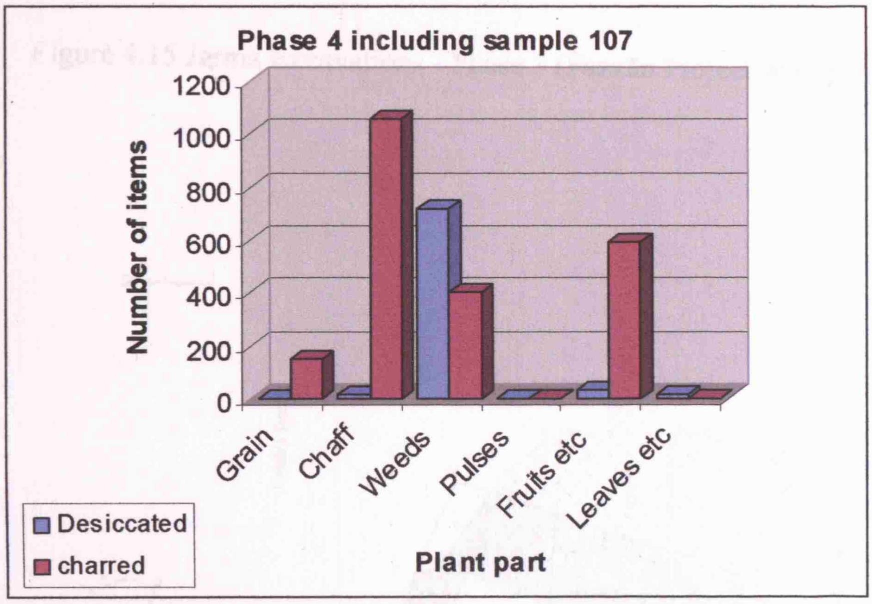

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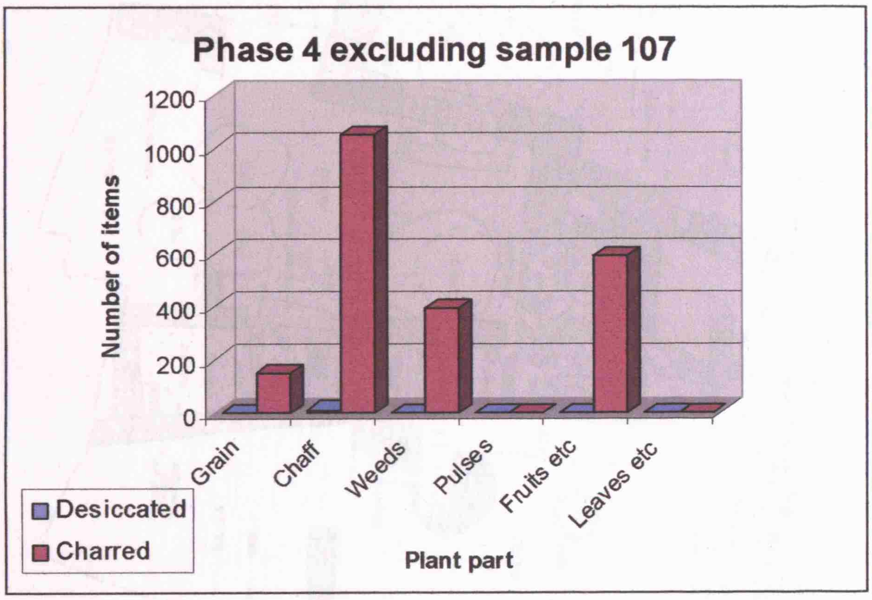

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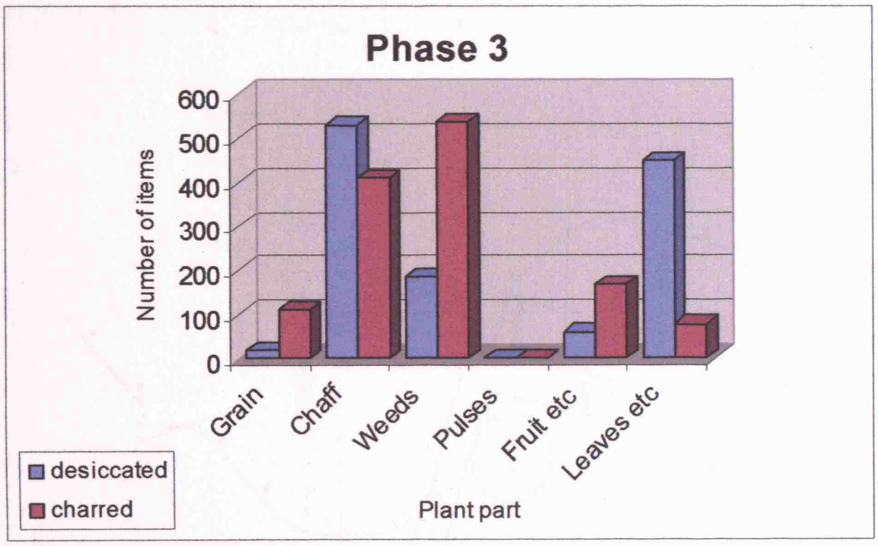

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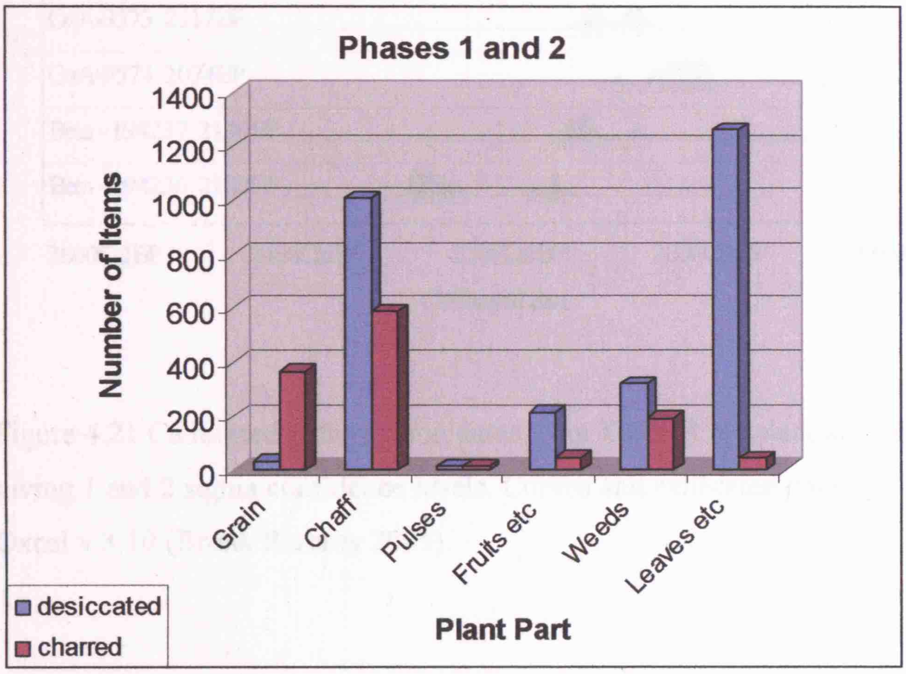

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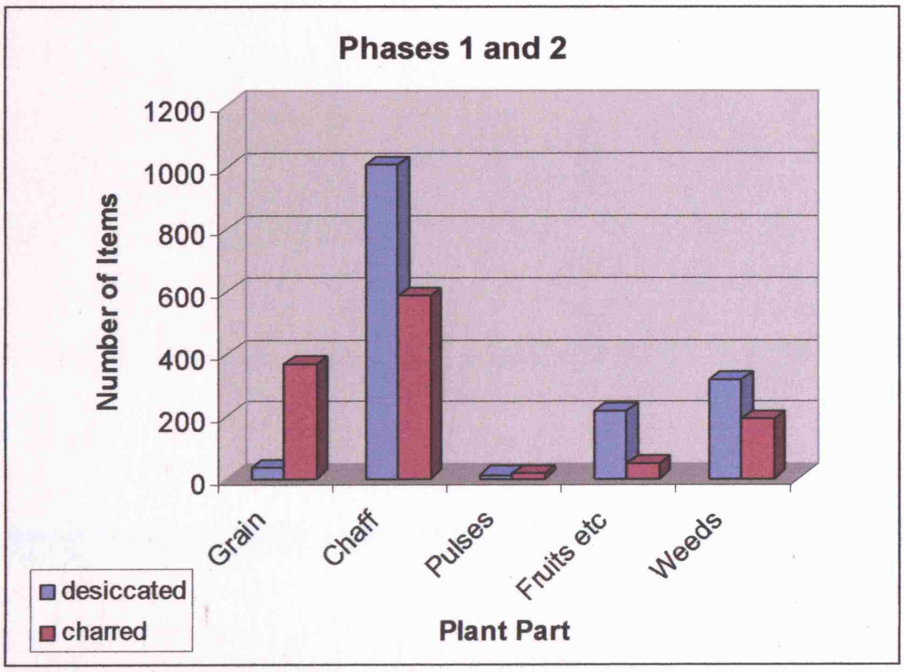

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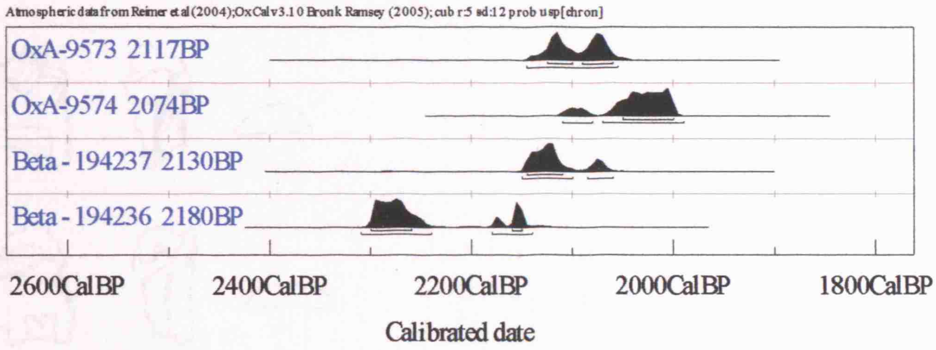

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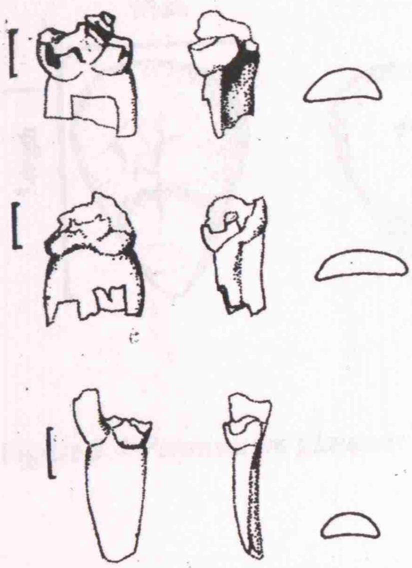

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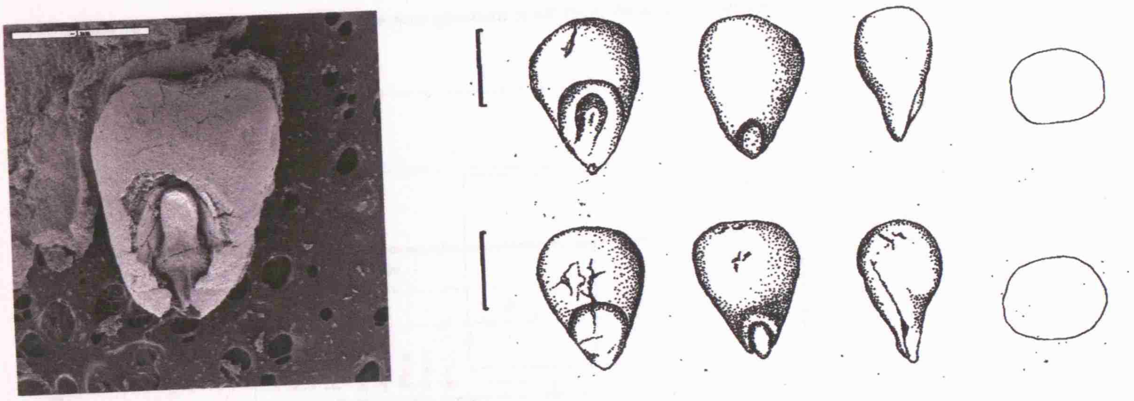

a b

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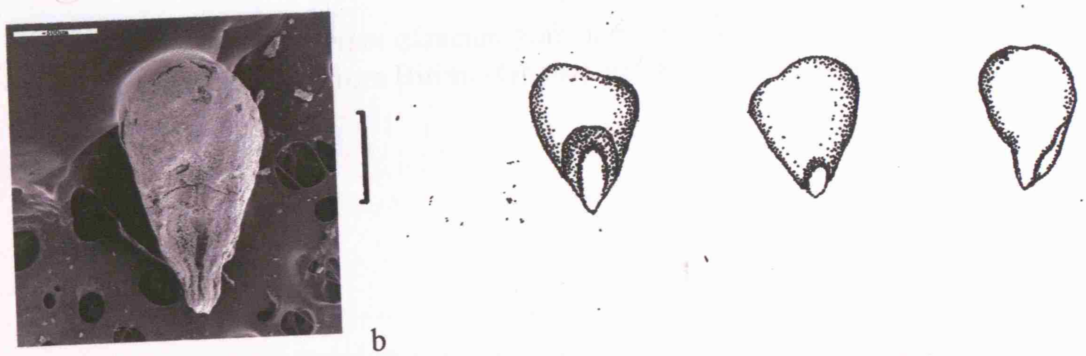

a b

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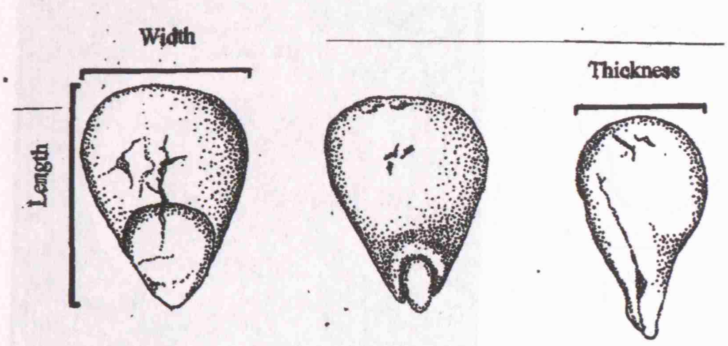

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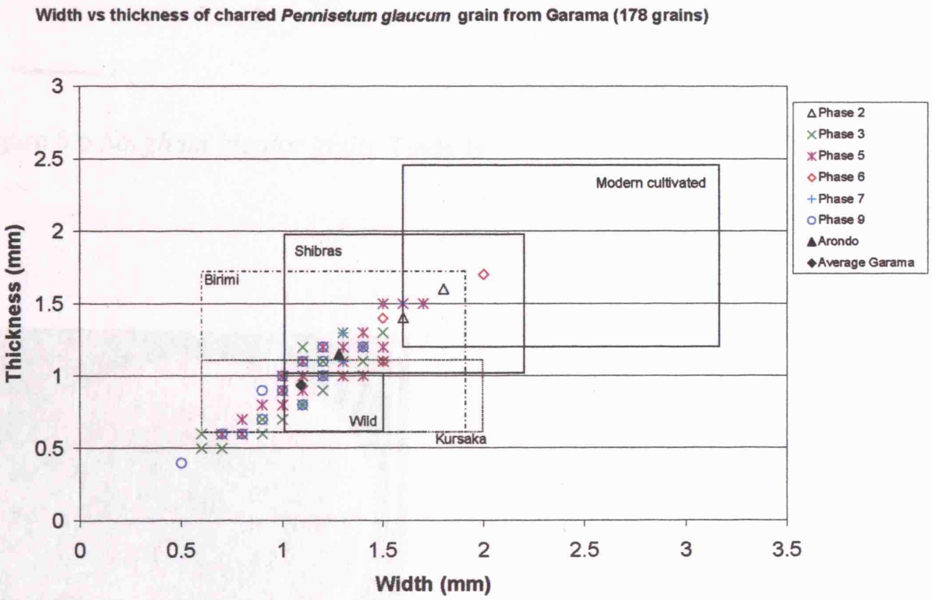

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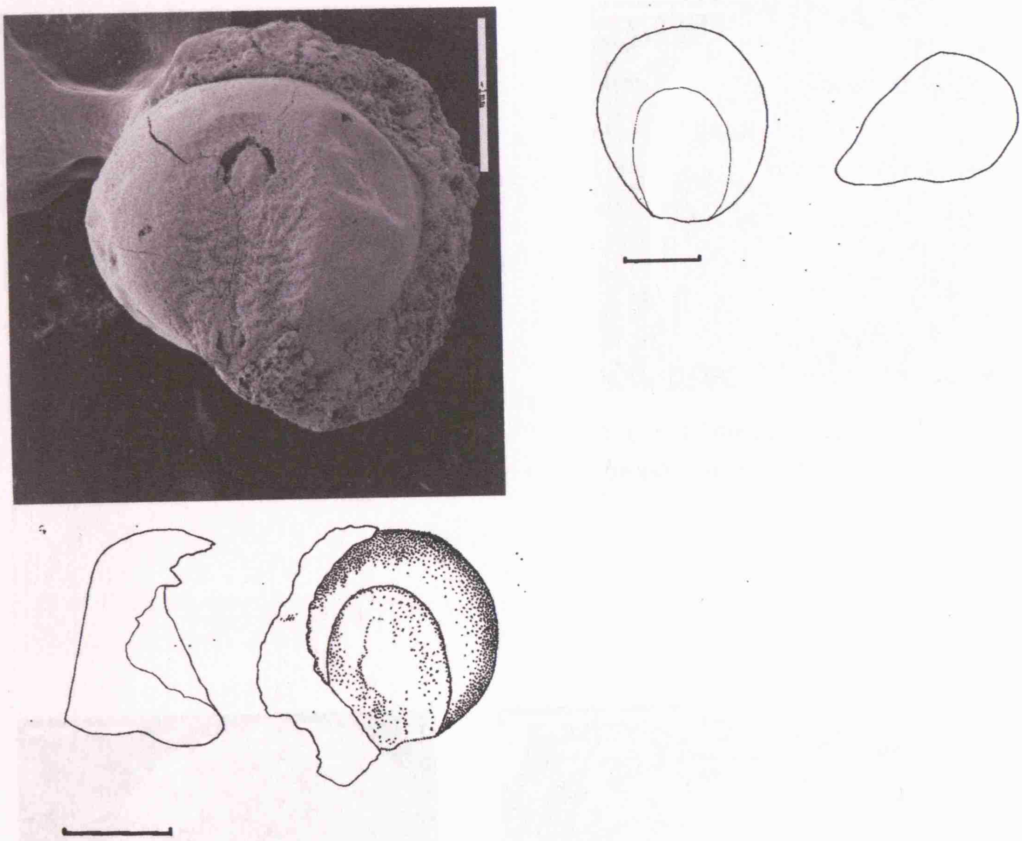

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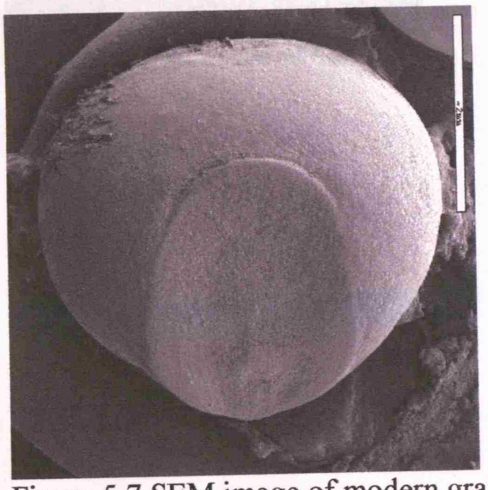

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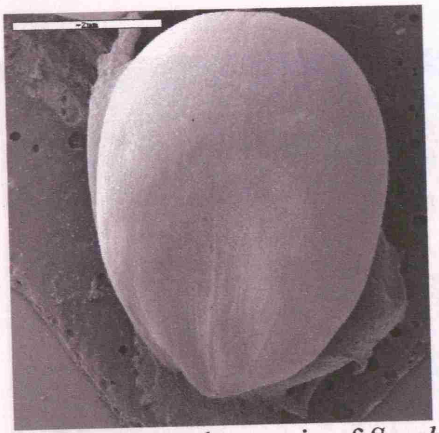

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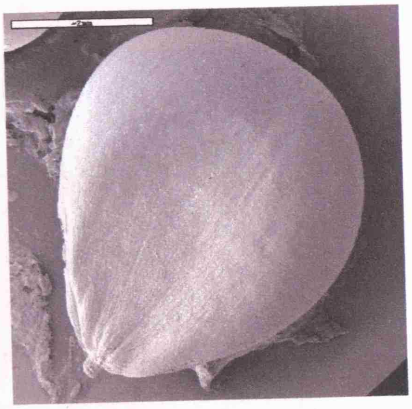

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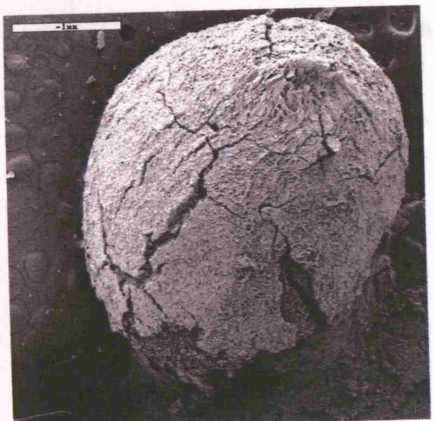

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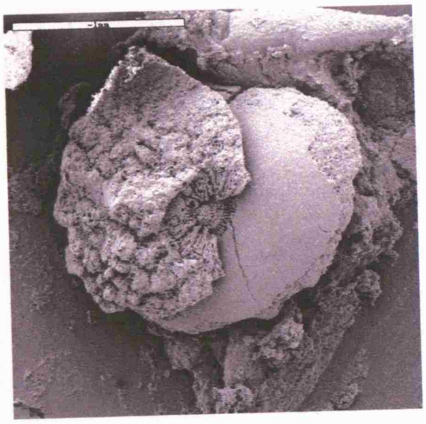

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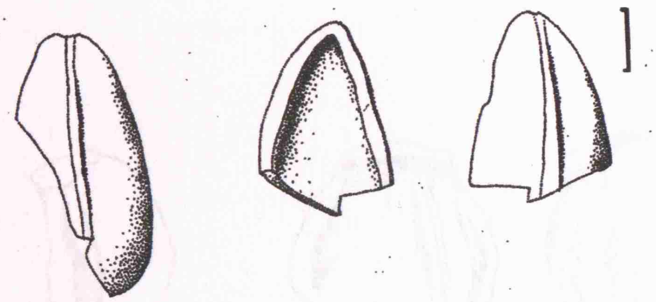

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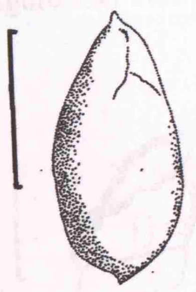

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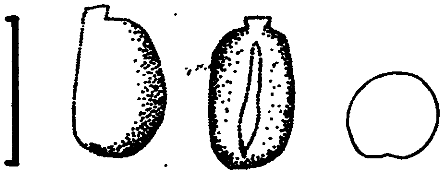

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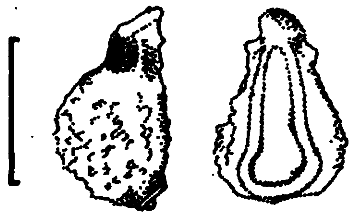

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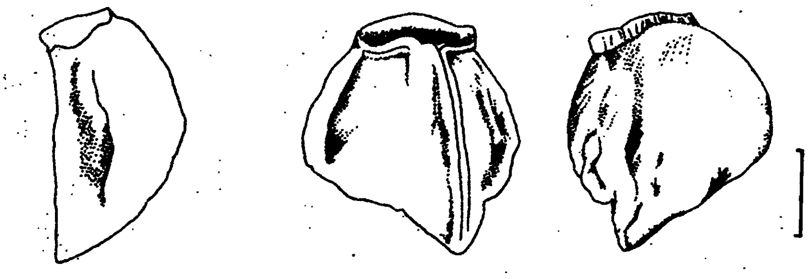

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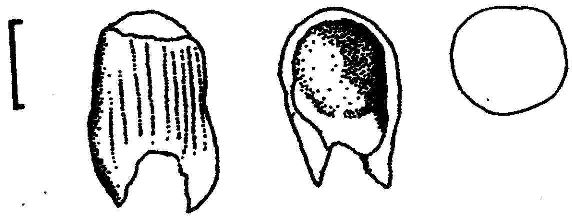

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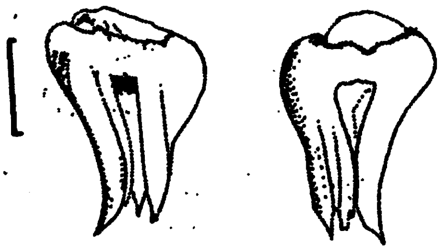

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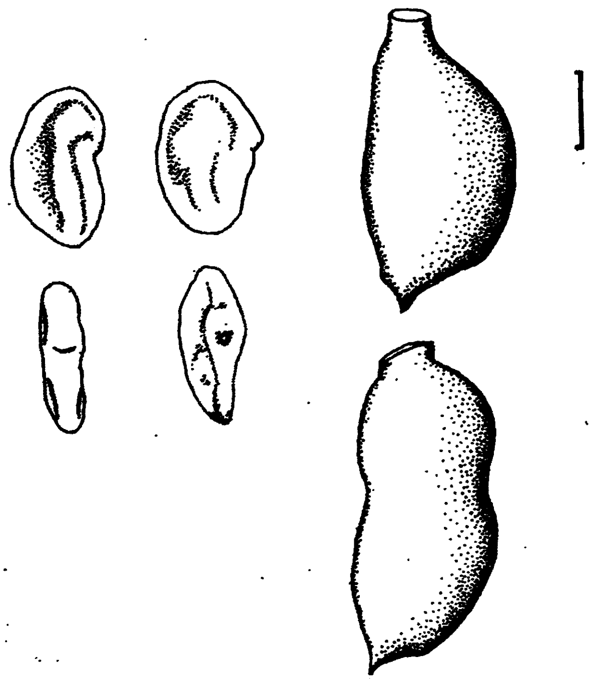

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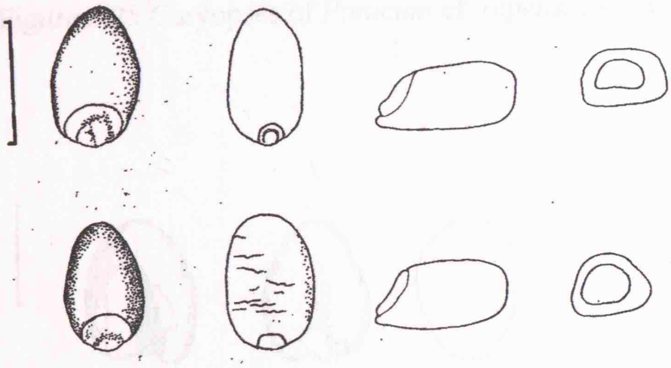

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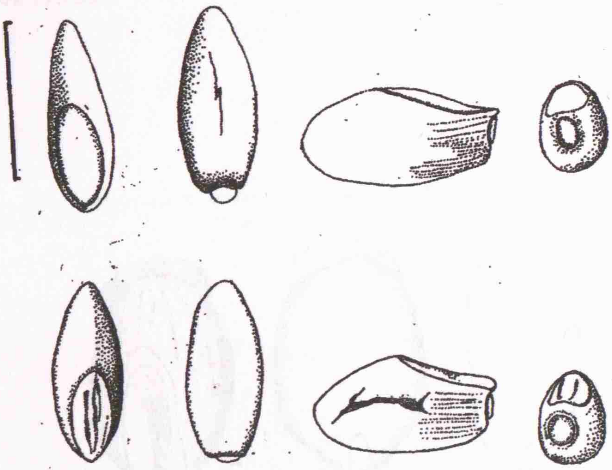

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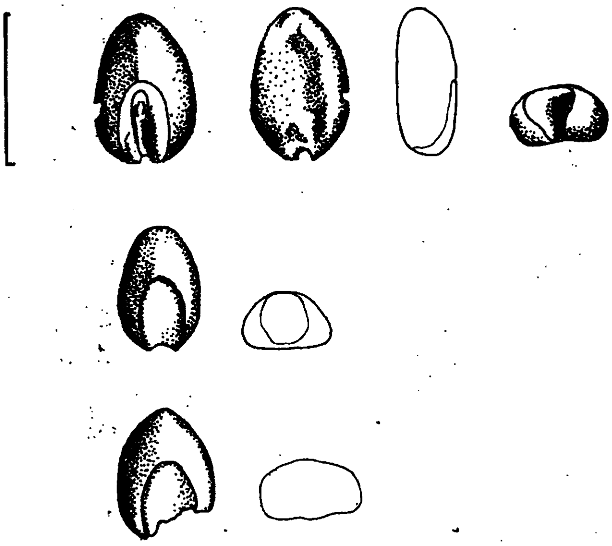

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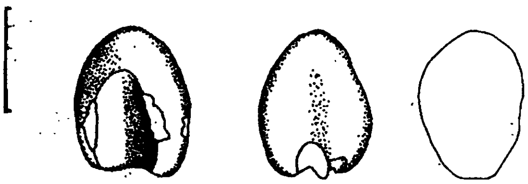

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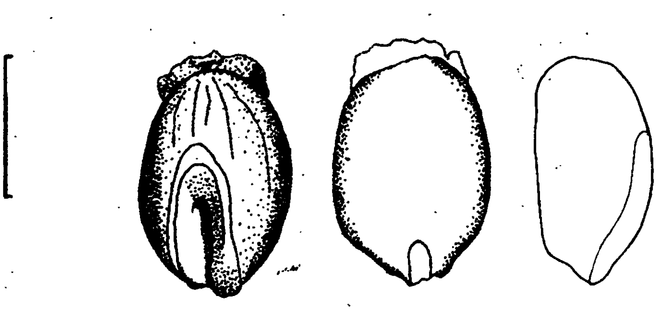

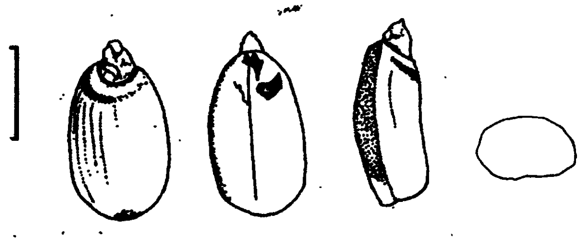

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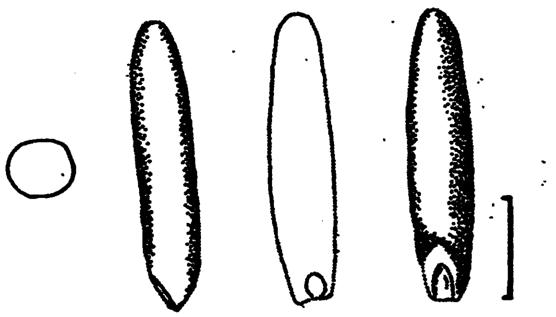

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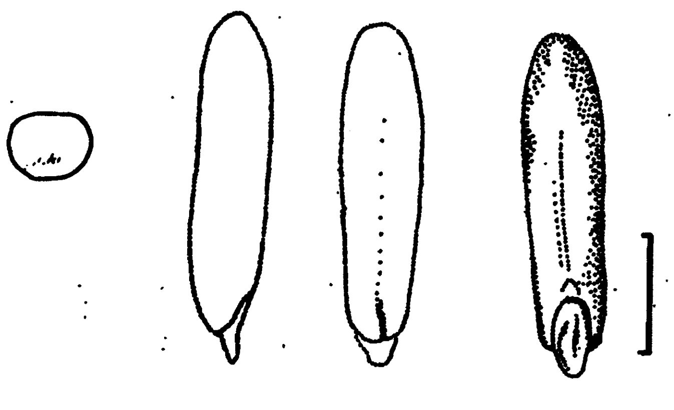

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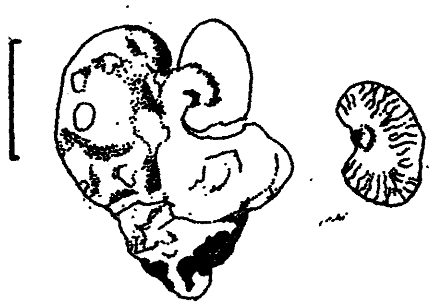

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Figure 5.33 Seed of *Reseda villosa/alba*, Jarma sample 07CF/549

Figure 5.34 Fruit of *Prosopis* sp., Jarma sample 03PF/106

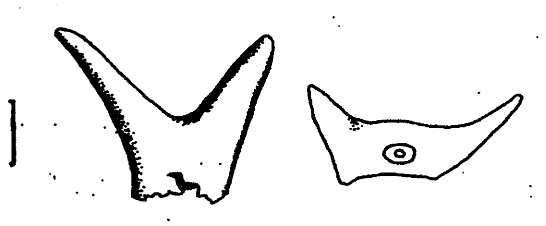


Figure 5.35 Paired thorn of cf. Mimosaceae type, Jarma sample 07CF/549

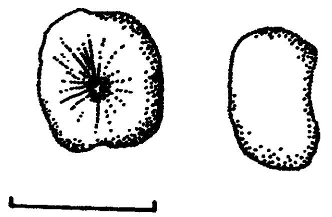


Figure 5.36 Seed of "Jarma type W", Jarma sample 06F/534

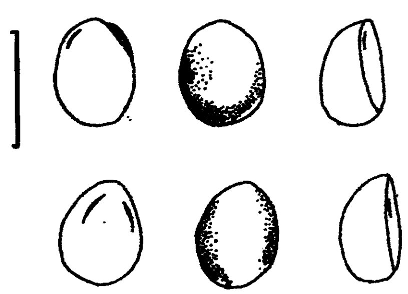


Figure 5.37 Seeds of "Jarma type T", Jarma sample 07CF/549

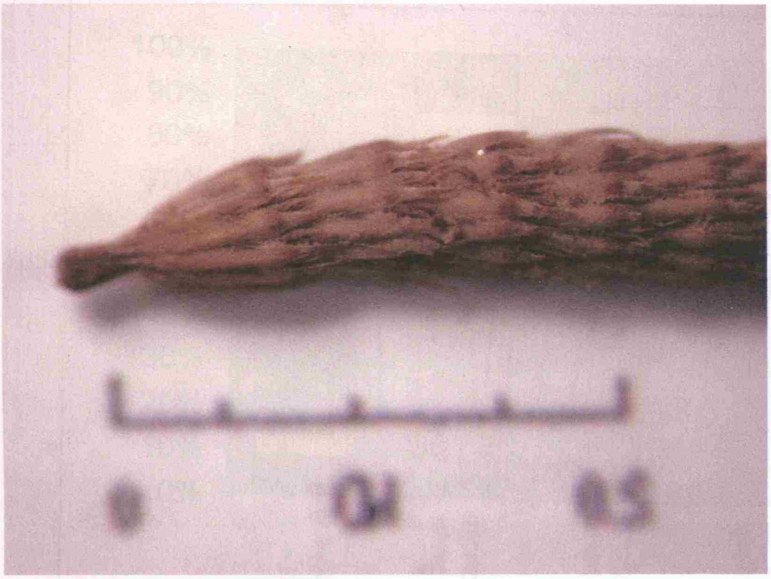


Figure 5.38 Stem fragments of *Myriophullym/Zylophyllum* sp., Jarma sample 01S/003

Figure 5.39 Spreading manure on fallow plots, Jarma 2001

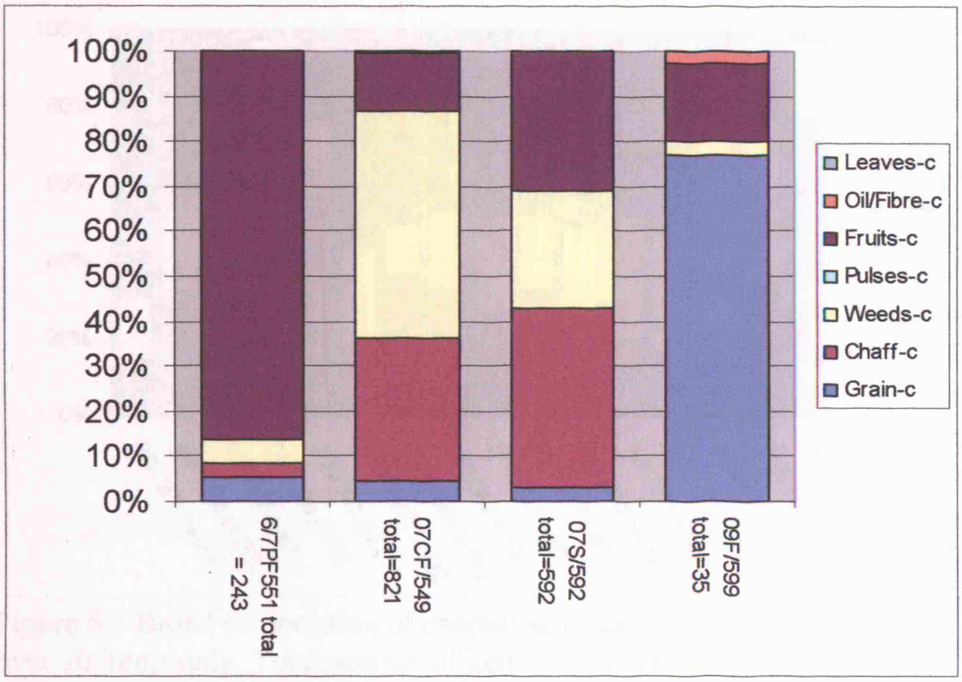


Figure 6.1 Broad composition of charred samples in phases 6/7 to10, showing samples with more than 30 items only. Total number of items is given.

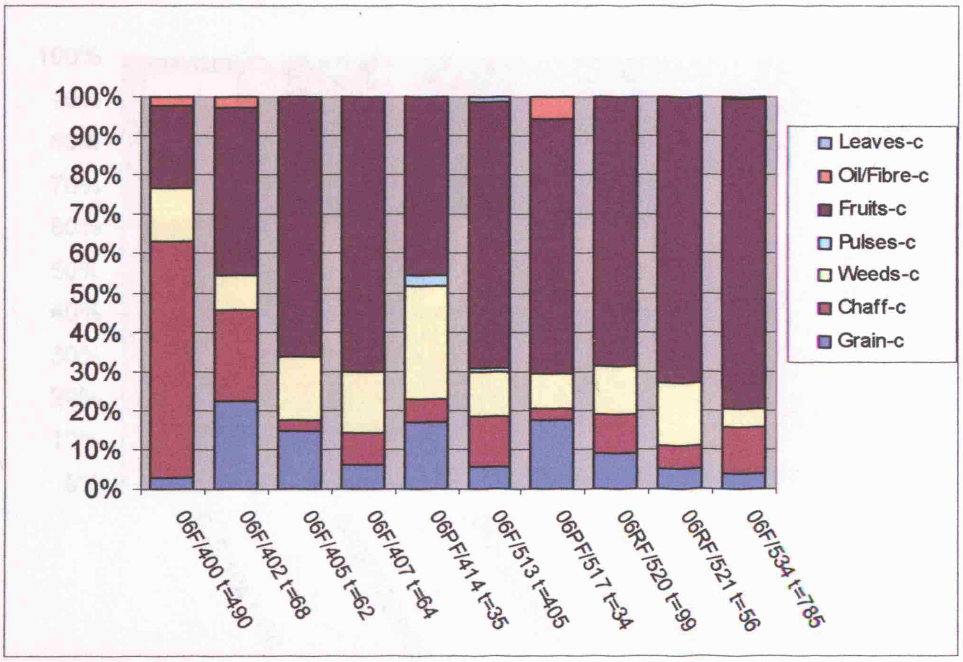


Figure 6.2 Broad composition of charred samples in phase 6, showing samples with over 30 items only. Total number of items is given by t.

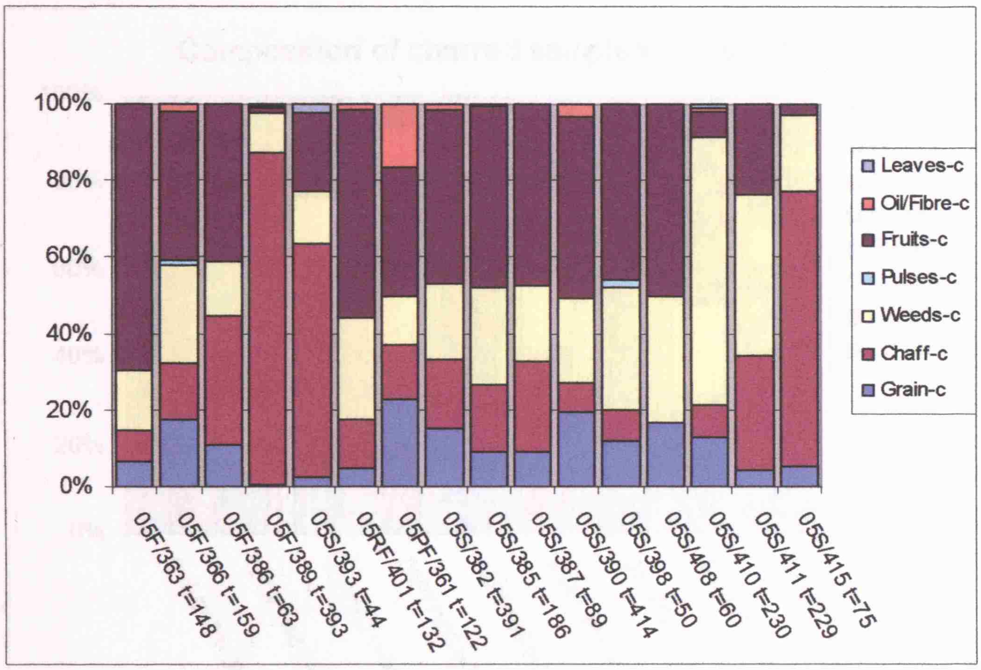


Figure 6.3 Broad composition of charred samples in phase 5, showing samples with over 30 items only. Total number of items is given by t.

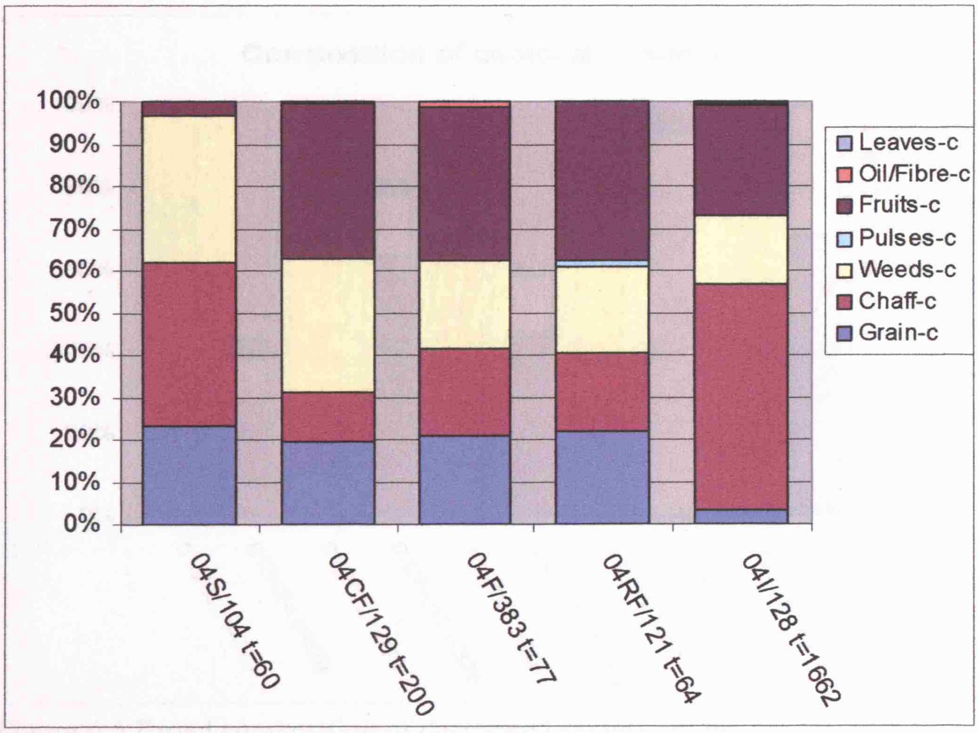


Figure 6.4 Broad composition of charred samples in phase 4, showing samples with over 30 items only. Total number of items is given by t

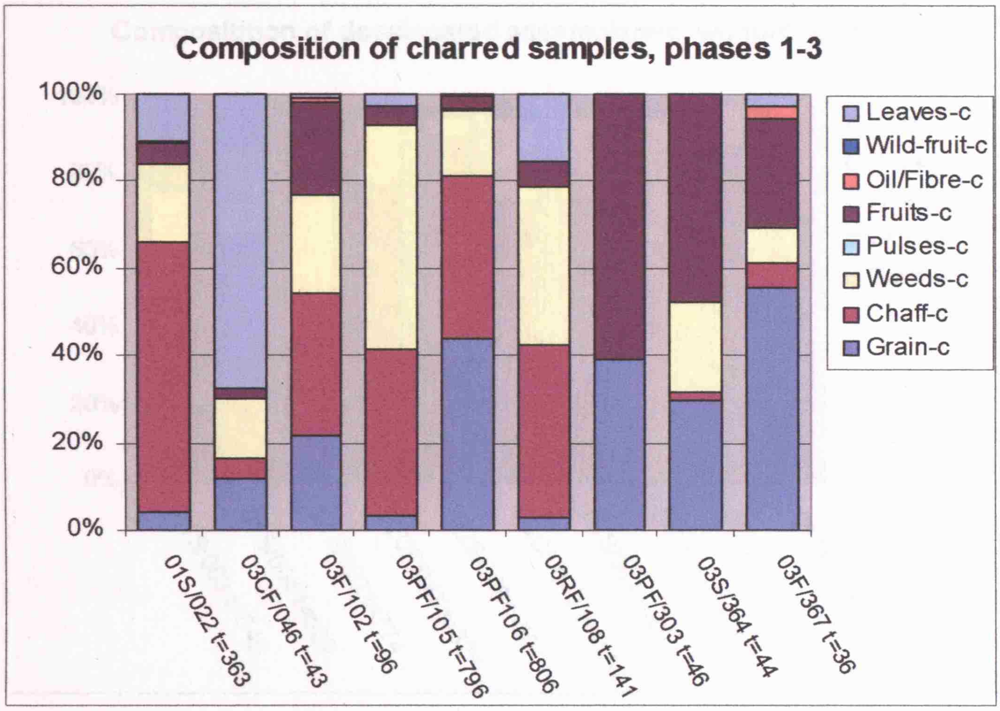


Figure 6.5 Broad composition of charred samples in phases 1to3, showing samples with over 30 items only. Total number of items is given by t

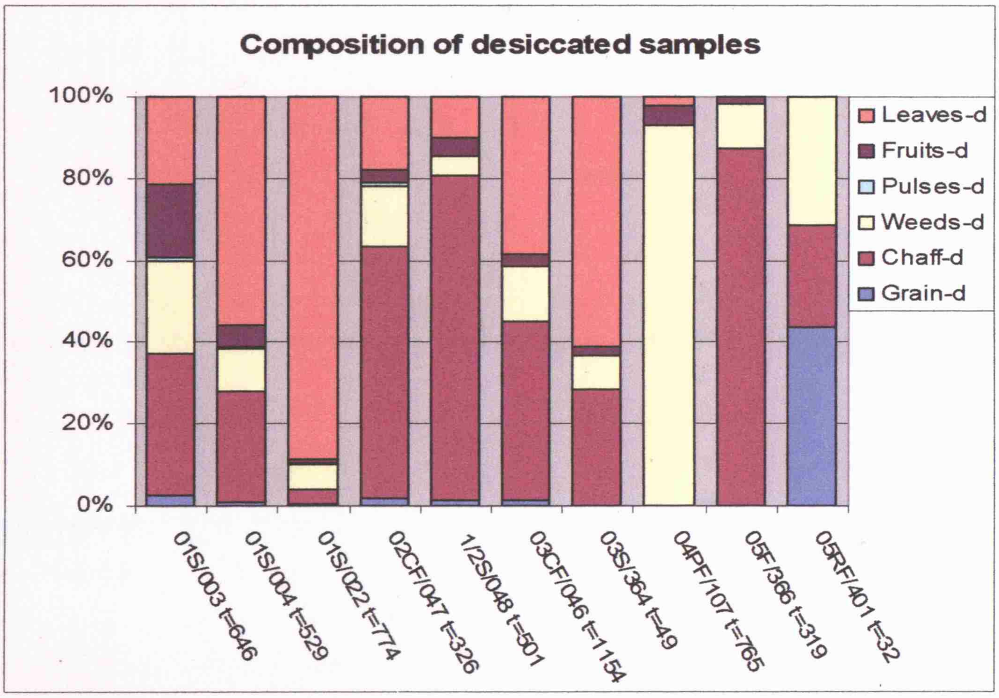


Figure 6.6 Broad composition of desiccated samples in phases 1to 3, showing samples with over 30 items only. Total number of items is given by t

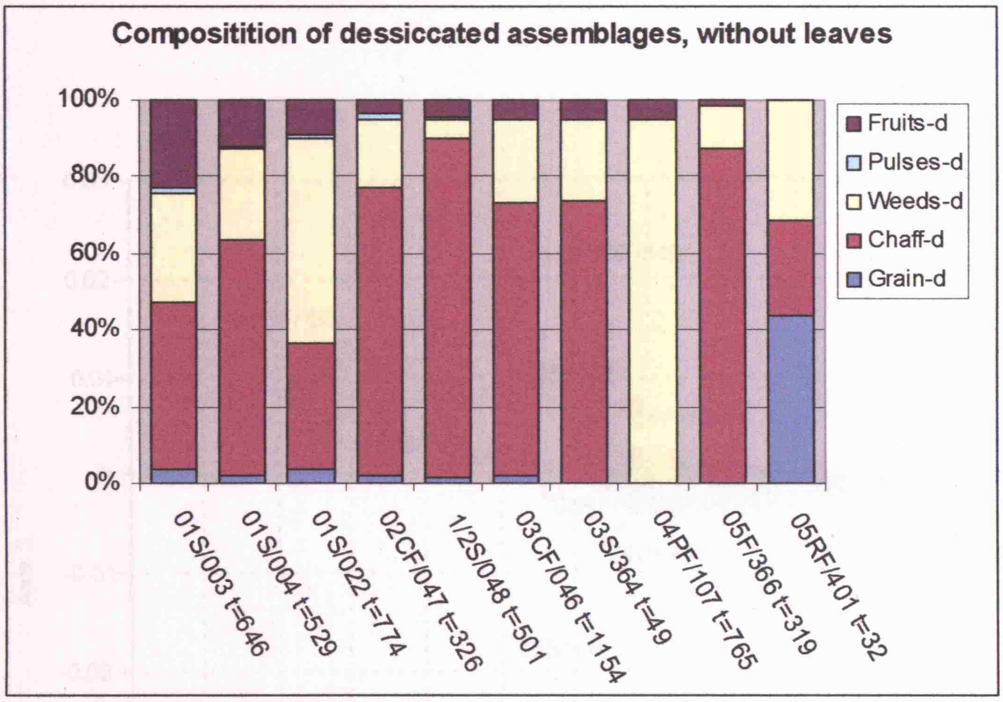


Figure 6.7 Broad composition of desiccated samples in phase 1-3 excluding leaves, showing samples with over 30 items only. Total number of items is given by t

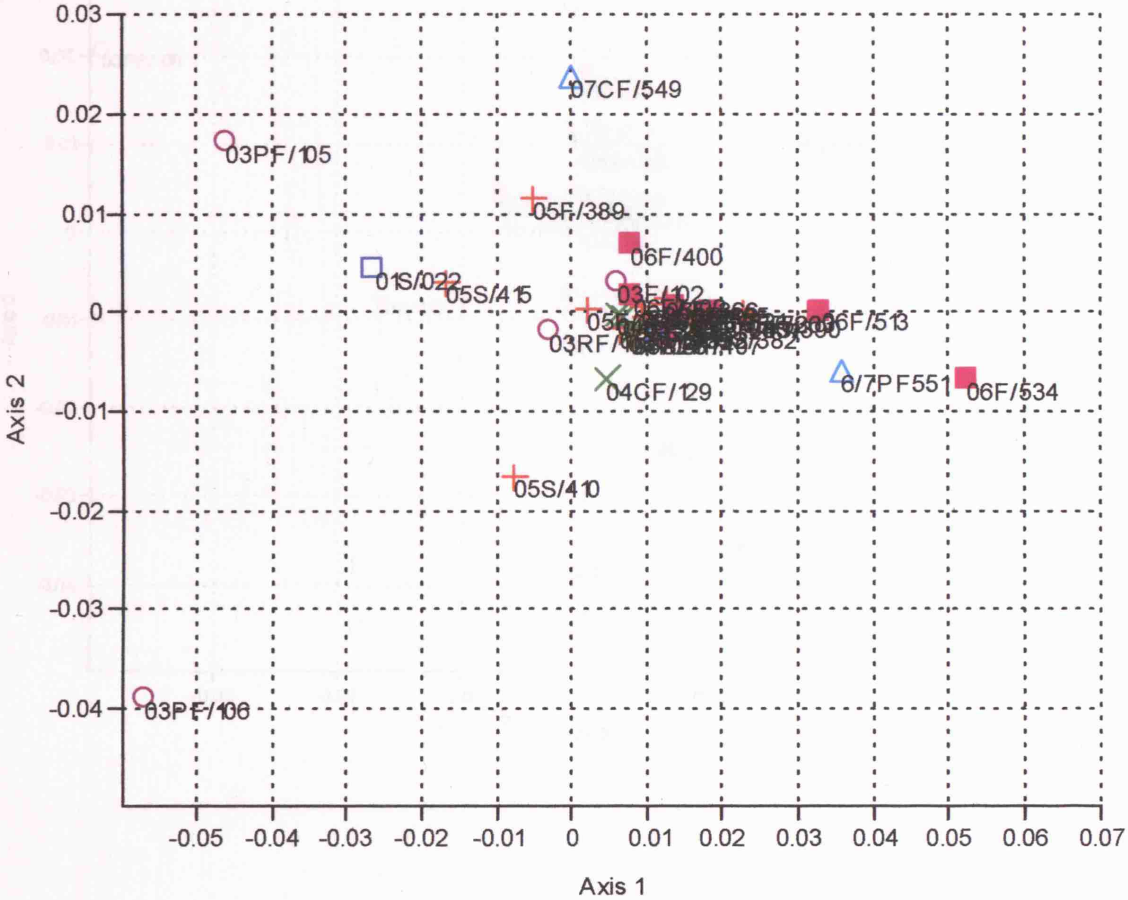


Figure 6.8 First Correspondence Analysis plot showing 34 samples with the 10% cut off point for rare taxa (74 taxa), 1st and 2nd axes. The following phase codes are used in all plots:

□ Phase 1 + Phase 5
○ Phase 3 ■ Phase 6
× Phase 4 △ Phase 6/7 - 7

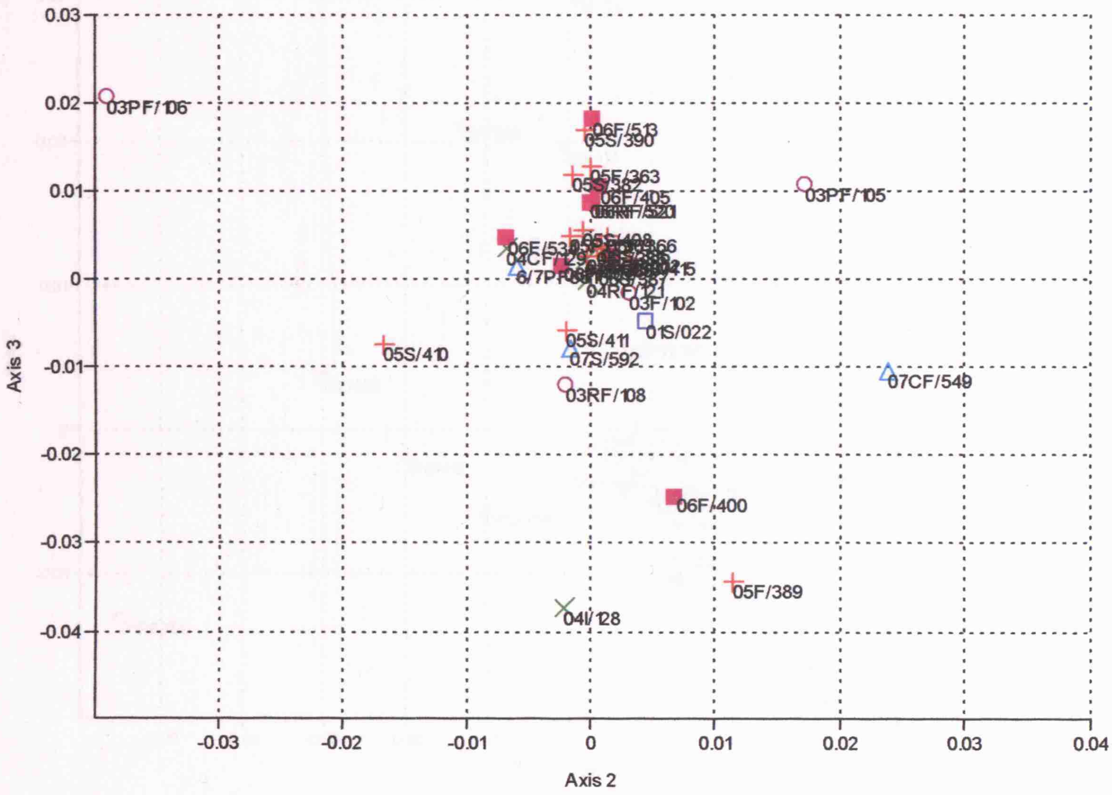


Figure 6.9 First Correspondence Analysis plot showing 34 samples with the 10% cut off point for rare taxa (74 taxa), 2nd and 3rd axes.

□ Phase 1 + Phase 5

○ Phase 3 ■ Phase 6

× Phase 4 △ Phase 6/7 - 7

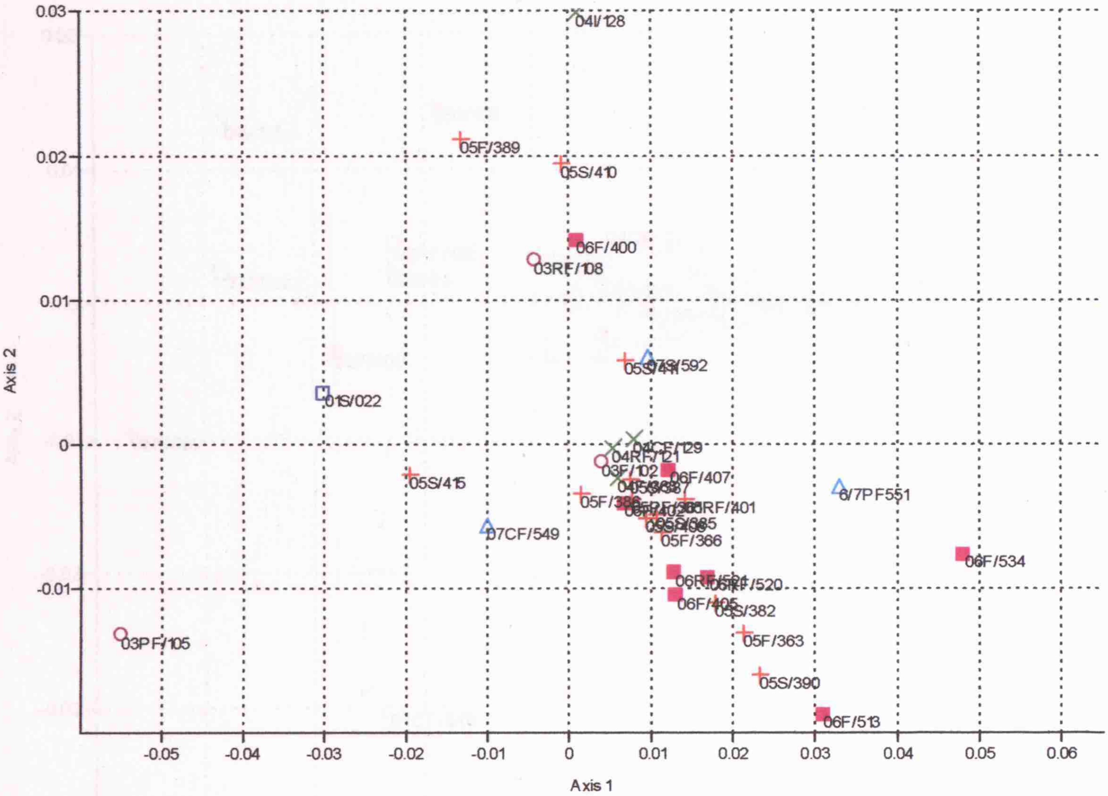


Figure 6.10 Correspondence Analysis plot after the removal of sample 03PF/106, 1st and 2nd axes.

□ Phase 1 + Phase 5

○ Phase 3 ■ Phase 6

× Phase 4 △ Phase 6/7 - 7

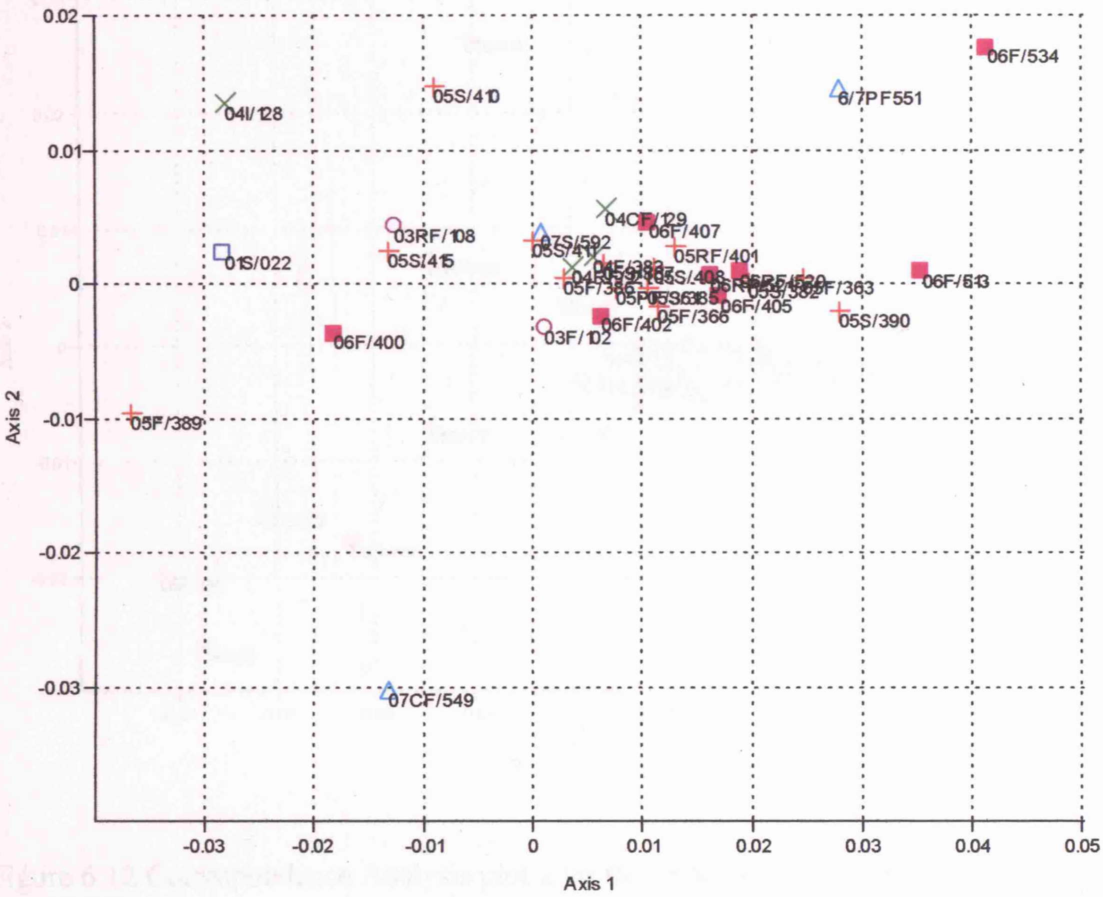


Figure 6.11 Correspondence Analysis plot after the removal of sample 03PF/105, 1st and 2nd axes.

□ Phase 1 + Phase 5

○ Phase 3 ■ Phase 6

× Phase 4 △ Phase 6/7 - 7

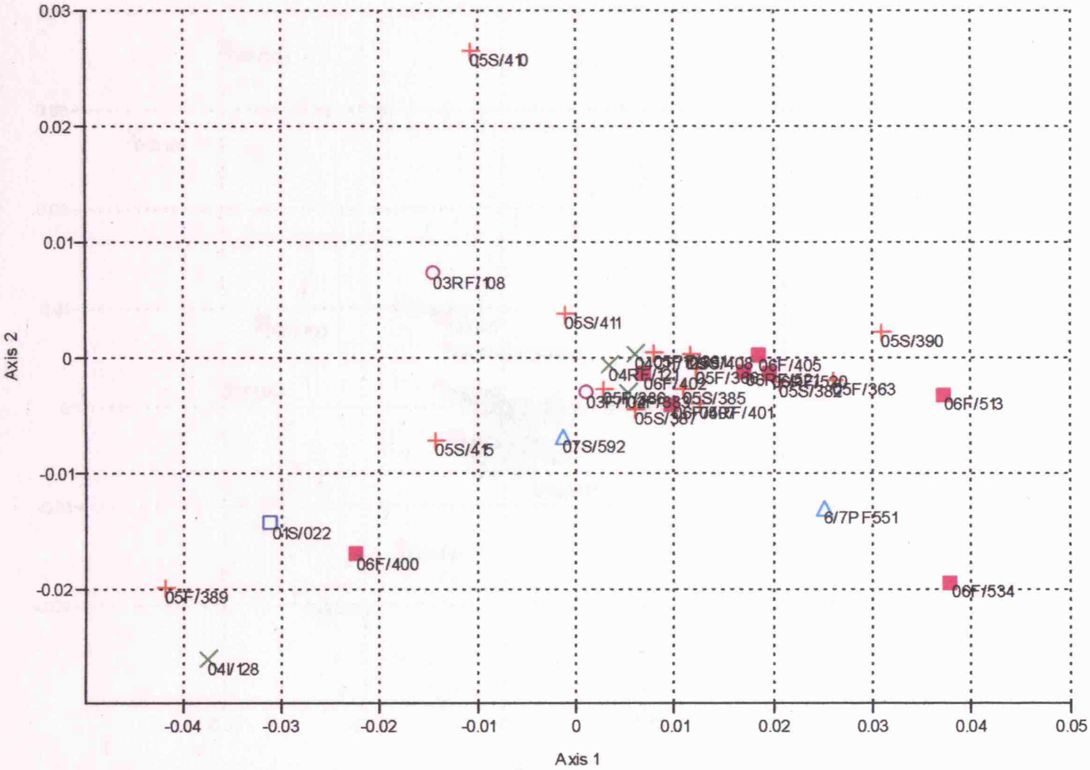


Figure 6.12 Correspondence Analysis plot after the removal of samples 03PF/106, 03PF/105, and 07CF/549, 1st and 2nd axes.

□ Phase 1 + Phase 5
○ Phase 3 ■ Phase 6
× Phase 4 △ Phase 6/7 - 7

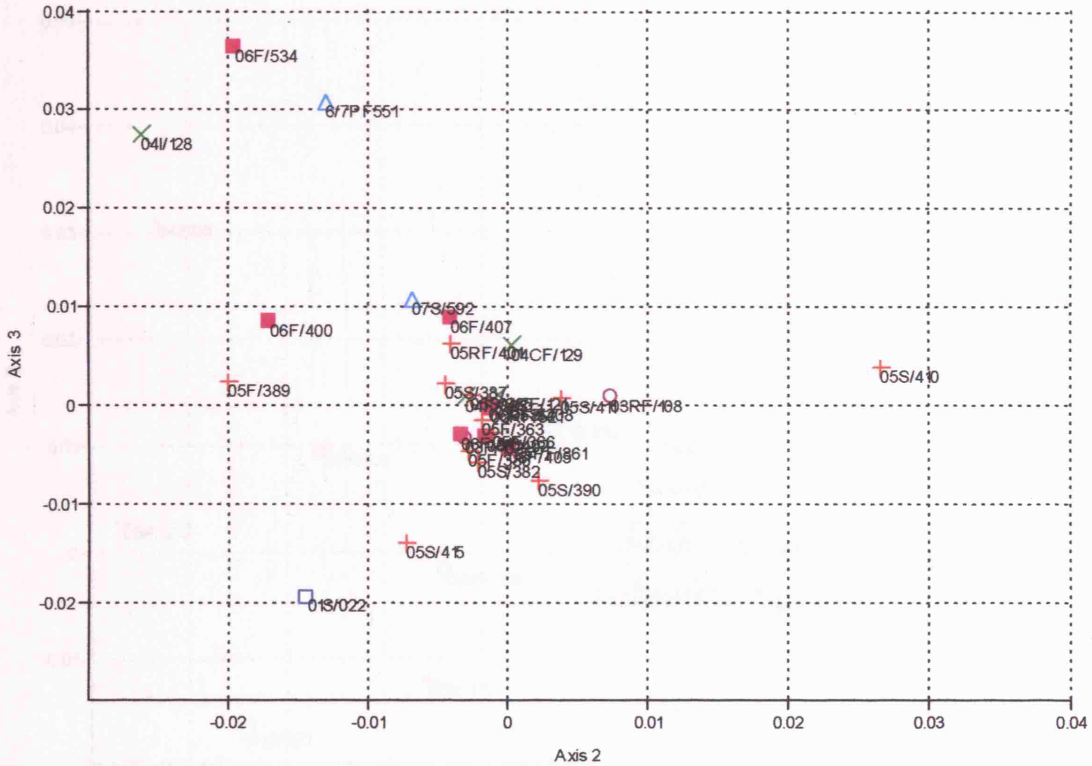


Figure 6.13 Correspondence Analysis plot after the removal of samples 03PF/106, 03PF/105, and 07CF/549, 2nd and 3rd axes.

□ Phase 1 + Phase 5

○ Phase 3 ■ Phase 6

× Phase 4 △ Phase 6/7 - 7

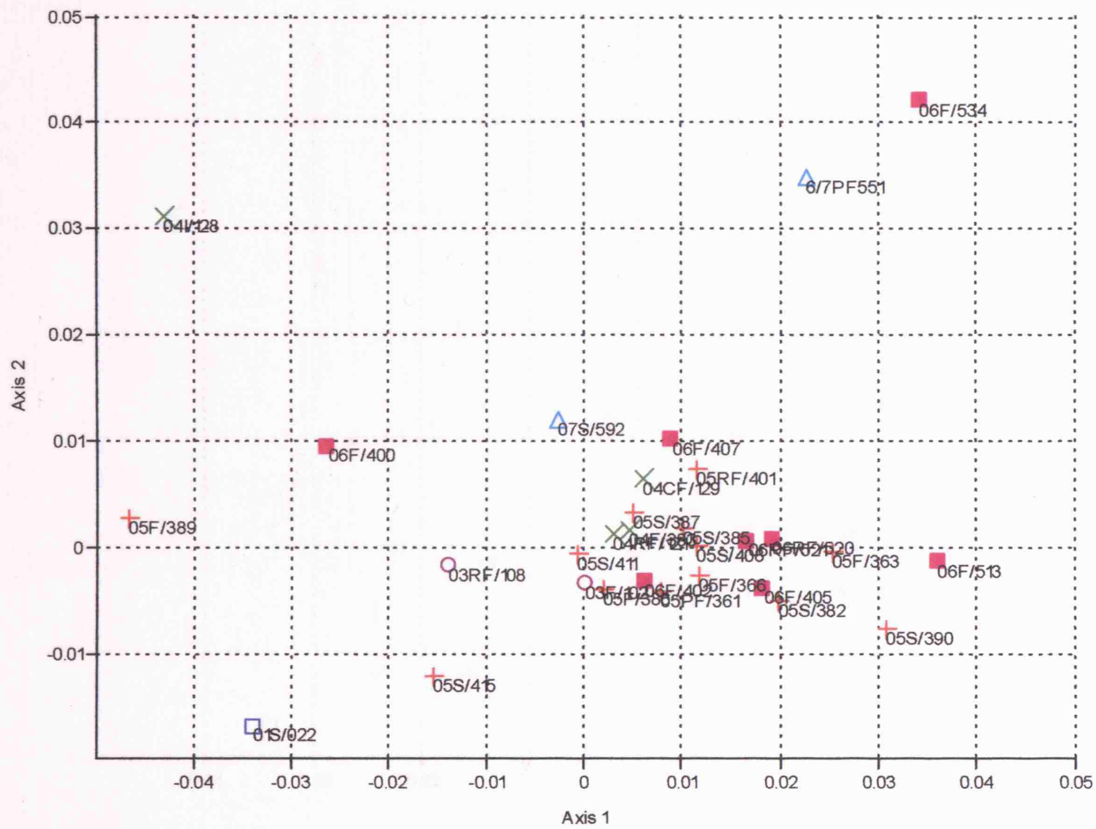


Figure 6.14 Correspondence Analysis plot after the removal of four outliers (samples 03PF/106, 03PF/105, 07CF/549 and 05S/410), 1st and 2nd axes.

□ Phase 1 + Phase 5

○ Phase 3 ■ Phase 6

× Phase 4 △ Phase 6/7 - 7

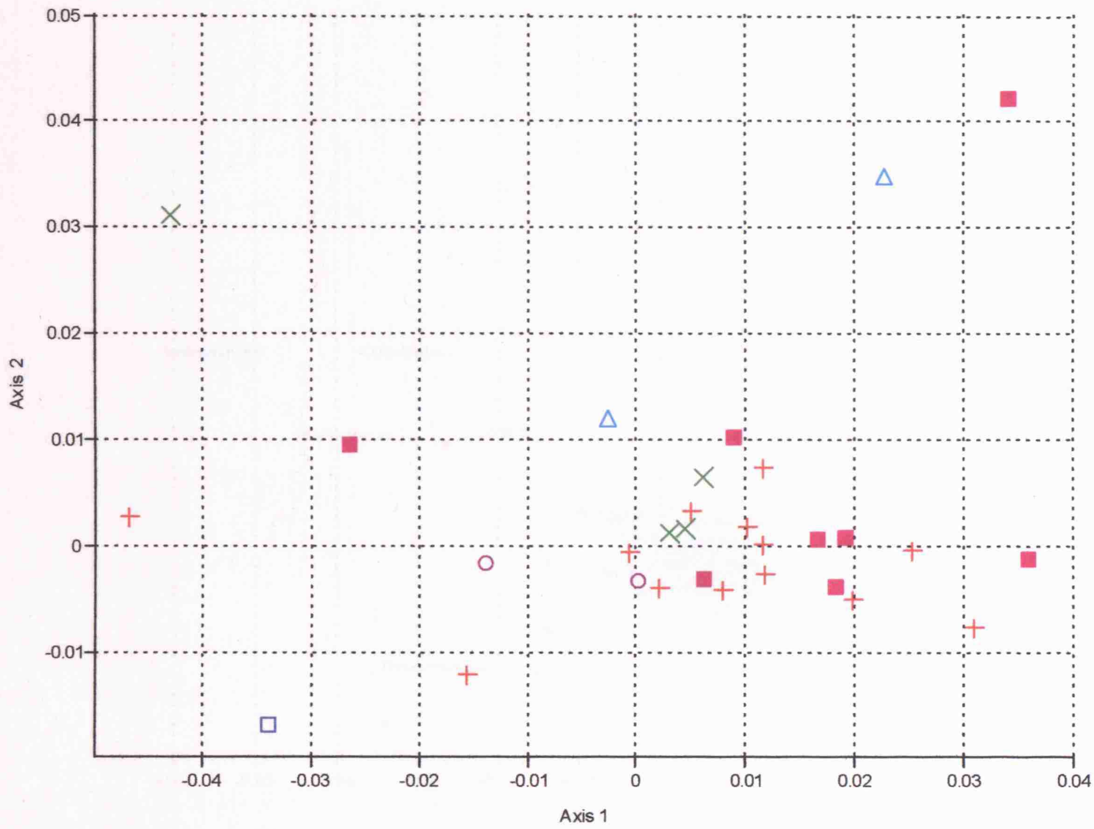


Figure 6.15 As Figure 6.14, Correspondence Analysis plot after the removal of four outliers (samples 03PF/106, 03PF/105, 07CF/549 and 05S/410), 1st and 2nd axes, without labels.

□ Phase 1   + Phase 5

○ Phase 3   ■ Phase 6

× Phase 4   △ Phase 6/7 - 7

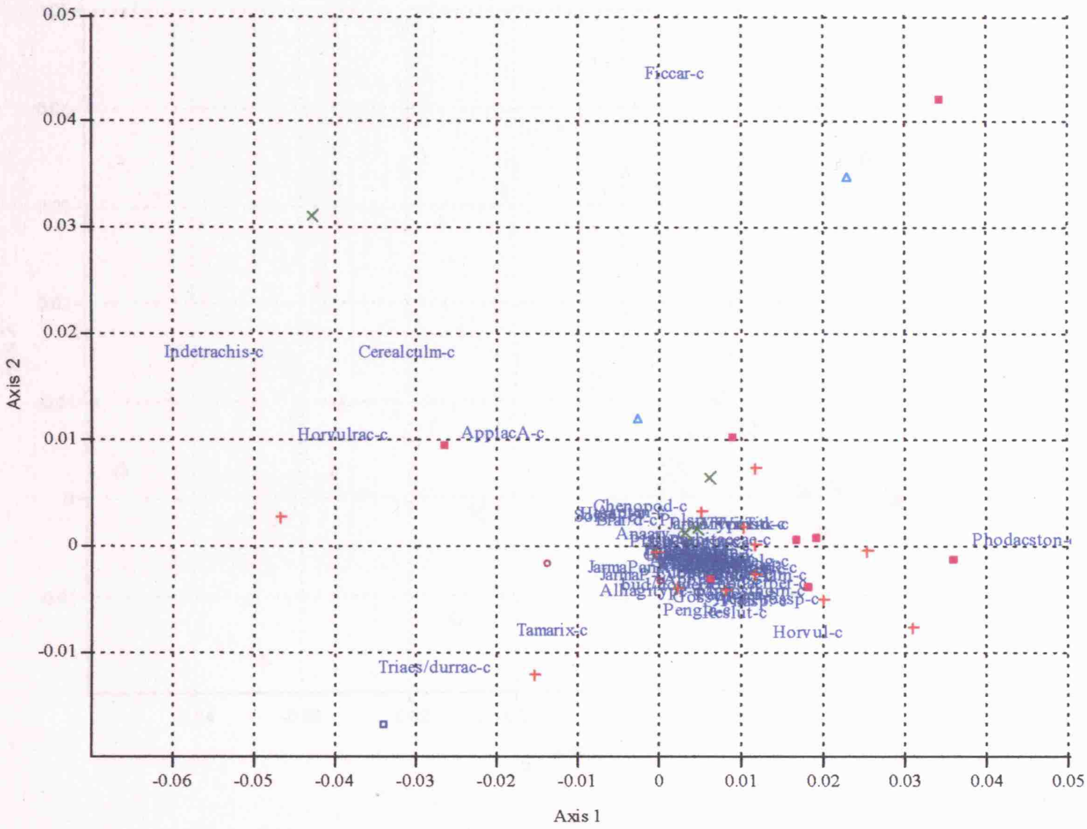


Fig 6.16 As Figure 6.14, Correspondence Analysis plot after the removal of four outliers (samples 03PF/106, 03PF/105, 07CF/549 and 05S/410), 1st and 2nd axes, showing taxa codes.

□ Phase 1 + Phase 5

○ Phase 3 ■ Phase 6

× Phase 4 △ Phase 6/7 - 7

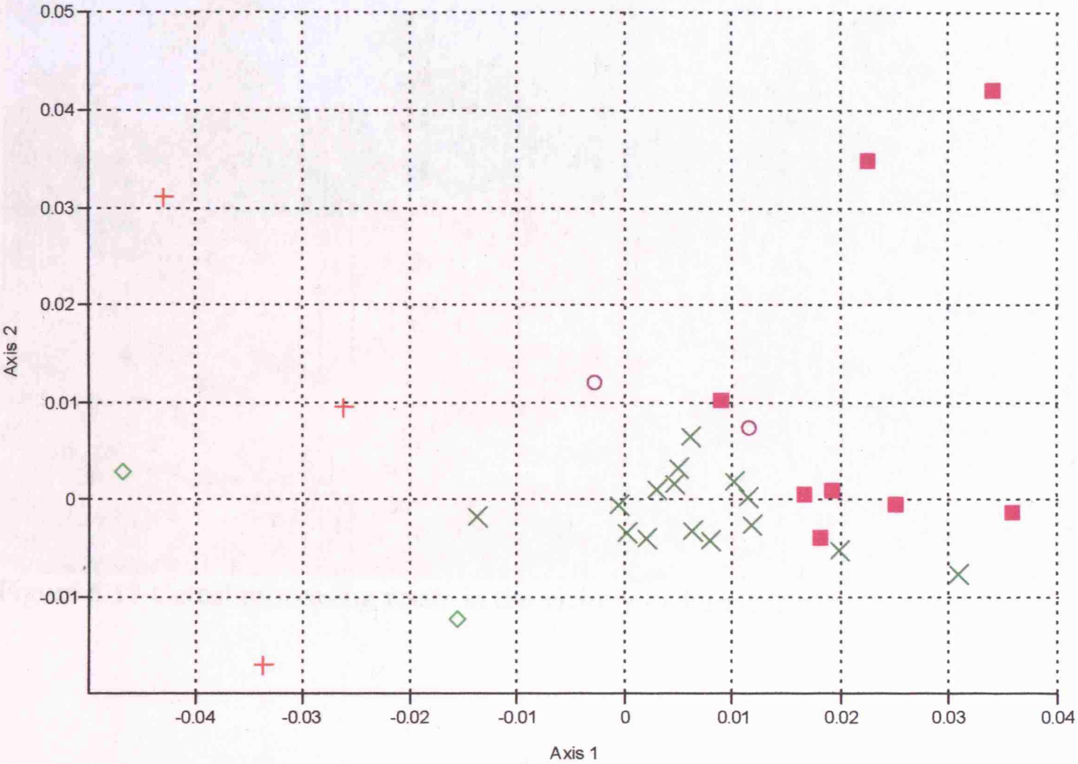


Fig 6.17 As Figure 6.14, Correspondence Analysis plot after the removal of four outliers (samples 03PF/106, 03PF/105, 07CF/549 and 05S/410), 1st and 2nd axes, showing codes for sample composition (chaff rich, fruit rich, mixed).

◊ Chaff forms more than 70%
\+ Chaff forms 50%
x Mixed, no category dominating
○ Fruit forms 50%
■ Fruit forms more than 70%

Figure 6.18 Cereal processing waste in the vicinity of Jarma, 2000

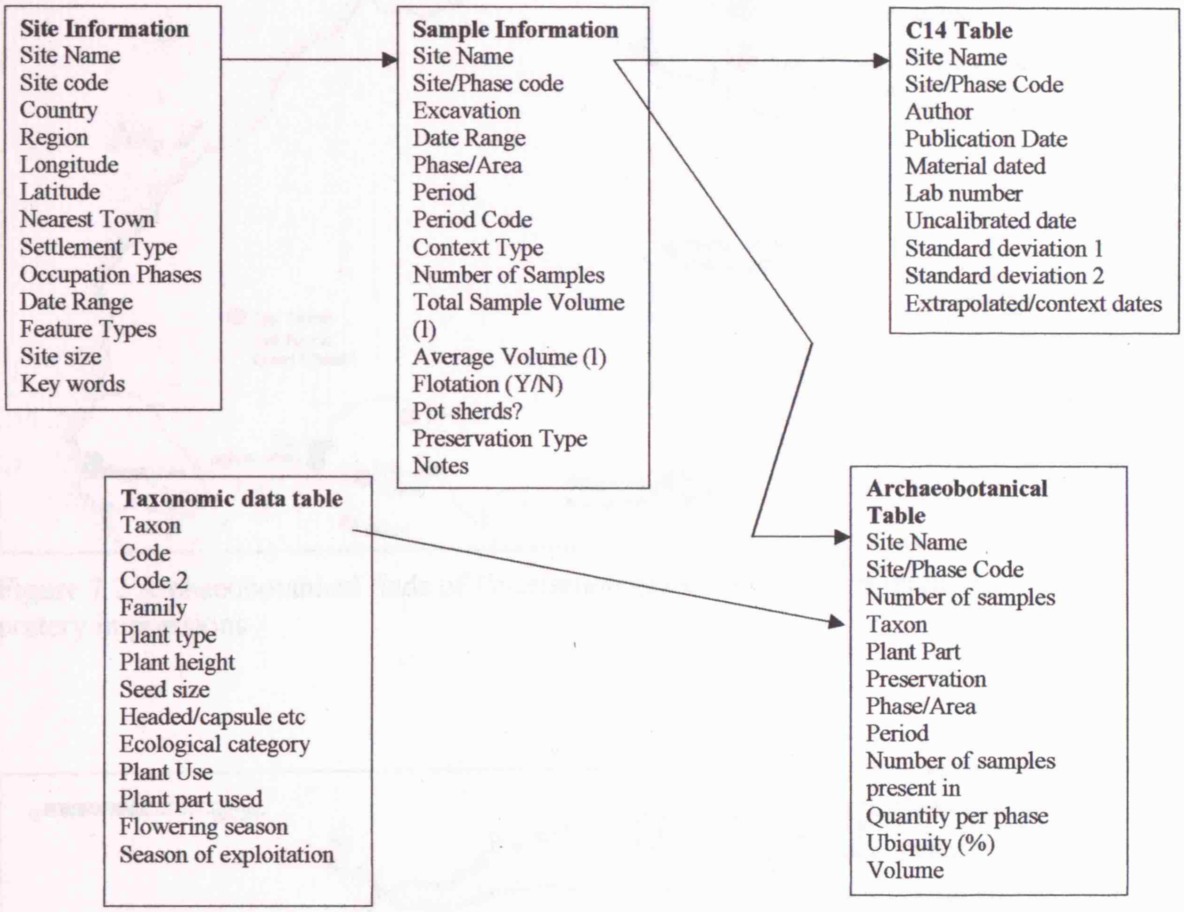


Figure 7.1 Model of the data base of African Archaeobotany

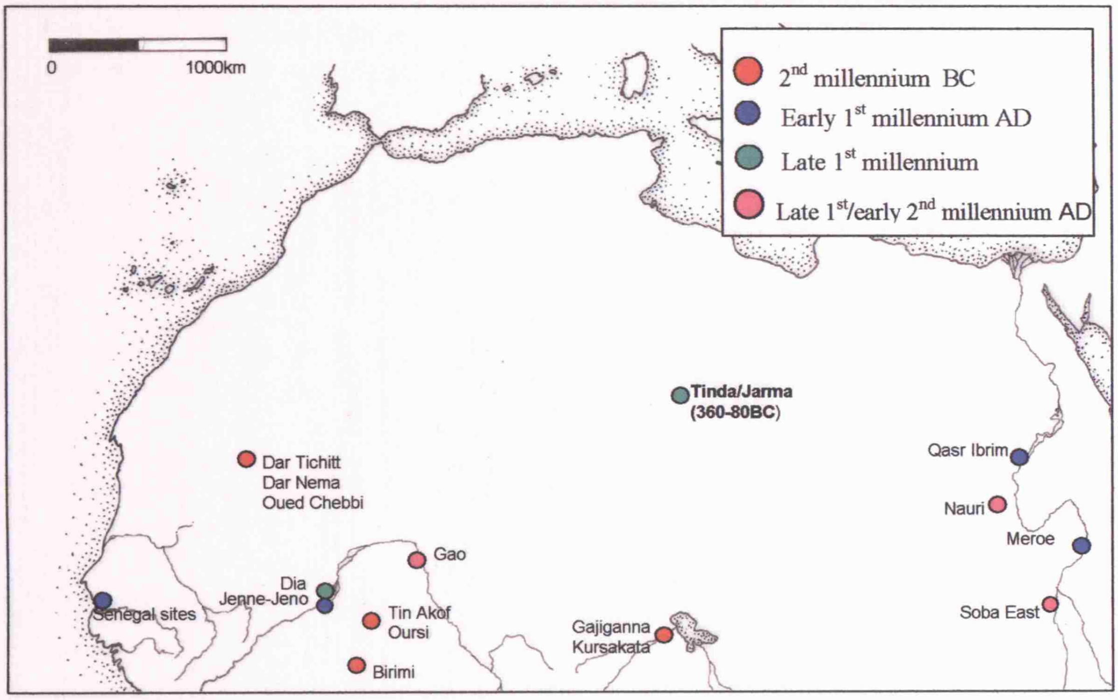


Figure 7.2 Archaeobotanical finds of *Pennisetum glaucum* caryopses including pottery impressions

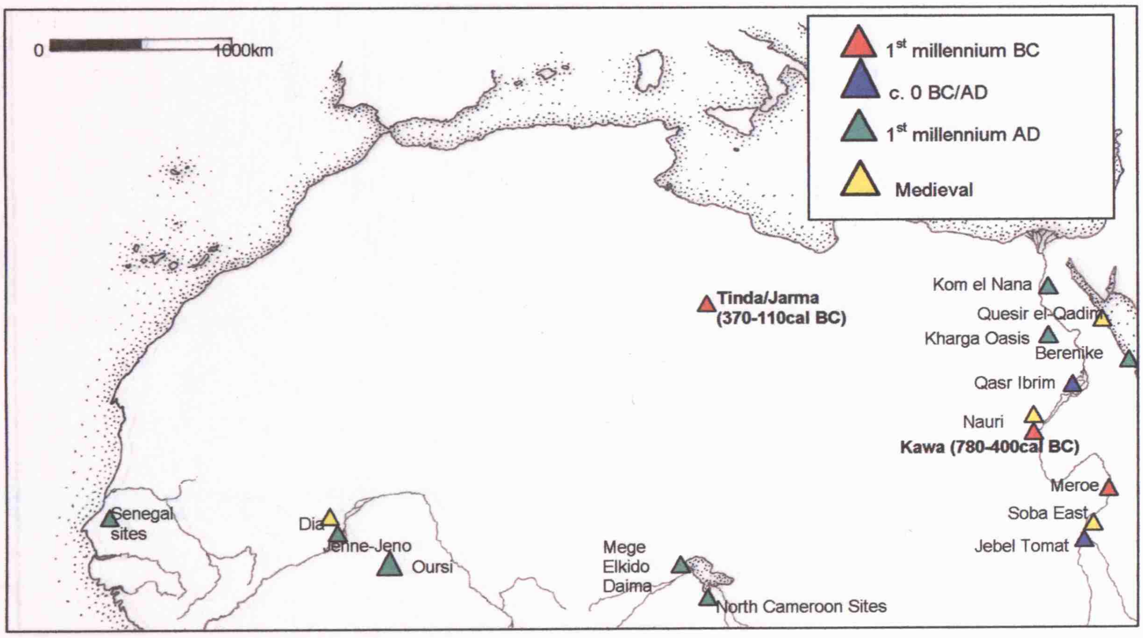


Figure 7.3 Archaeobotanical finds of domesticated *Sorghum bicolor* in Northern Africa

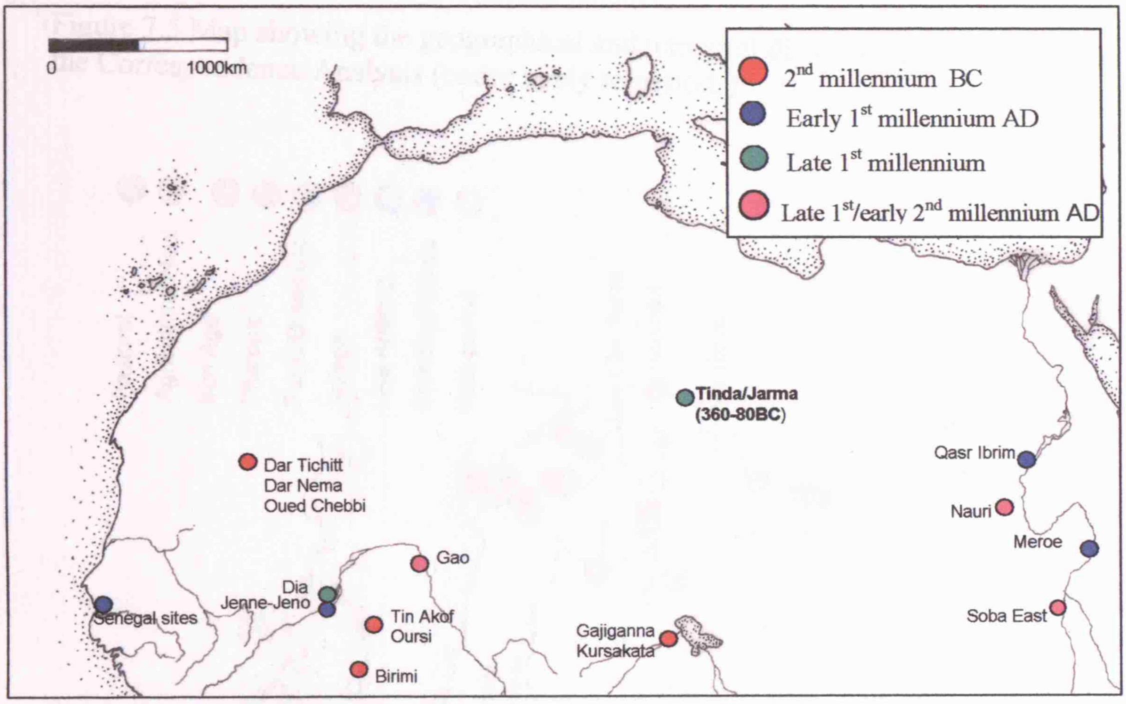


Figure 7.2 Archaeobotanical finds of *Pennisetum glaucum* caryopses including pottery impressions

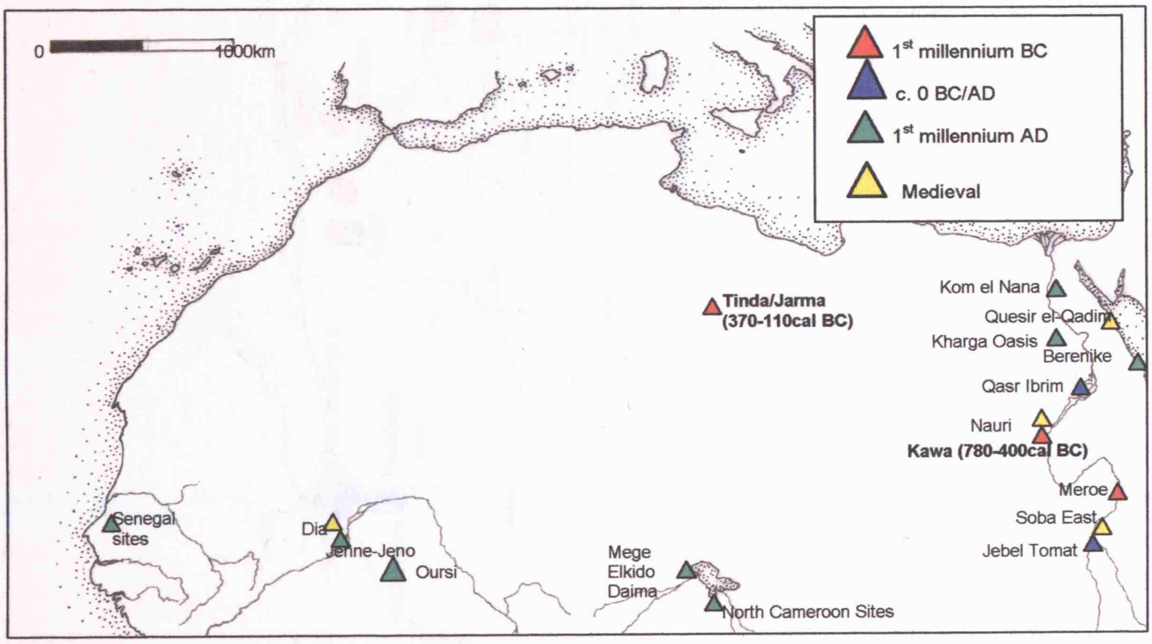
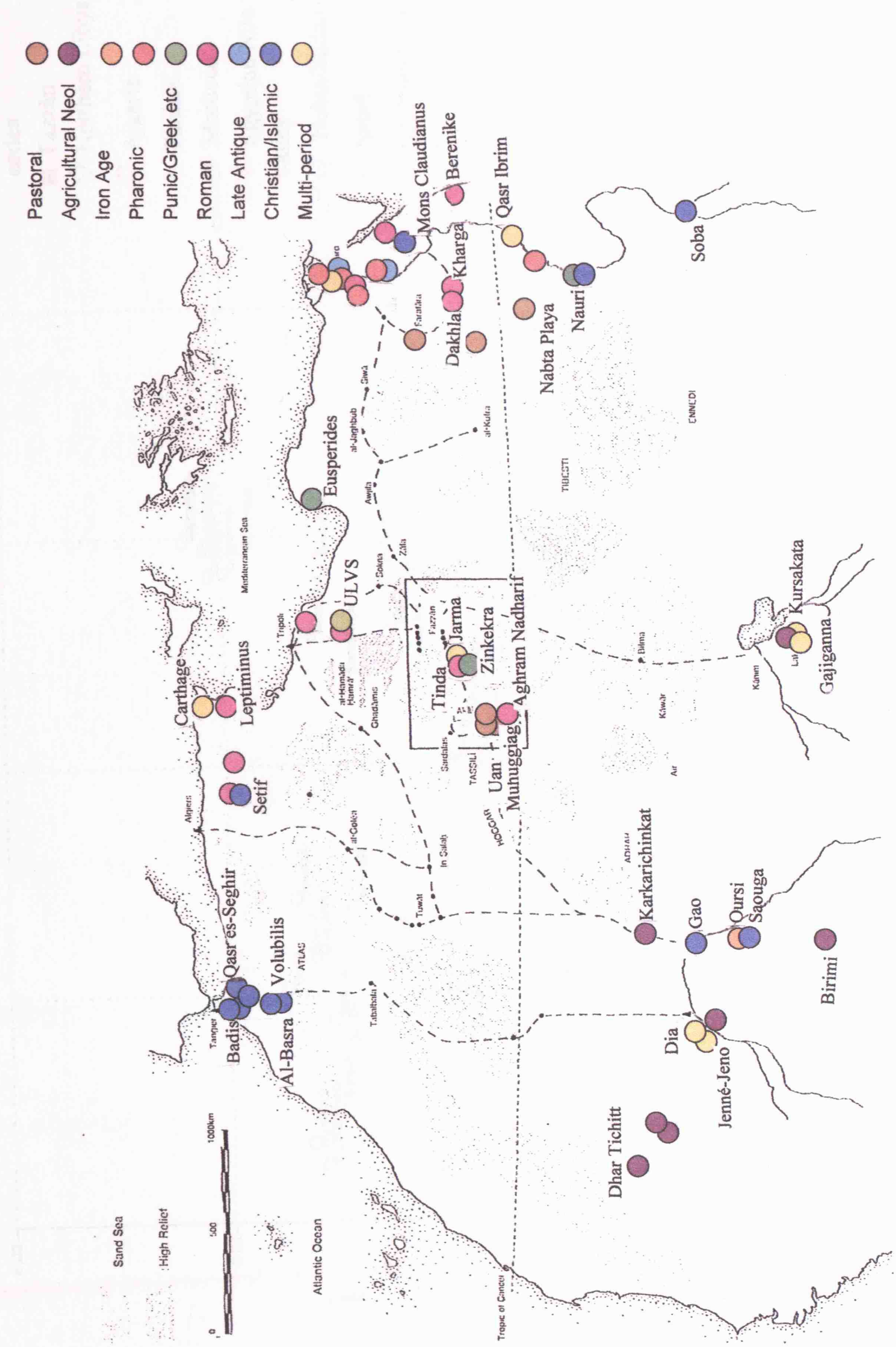


Figure 7.3 Archaeobotanical finds of domesticated *Sorghum bicolor* in Northern Africa

Figure 7.5 Map showing the geographical and temporal distribution of sites used in the Correspondence Analysis (codes apply to periods)



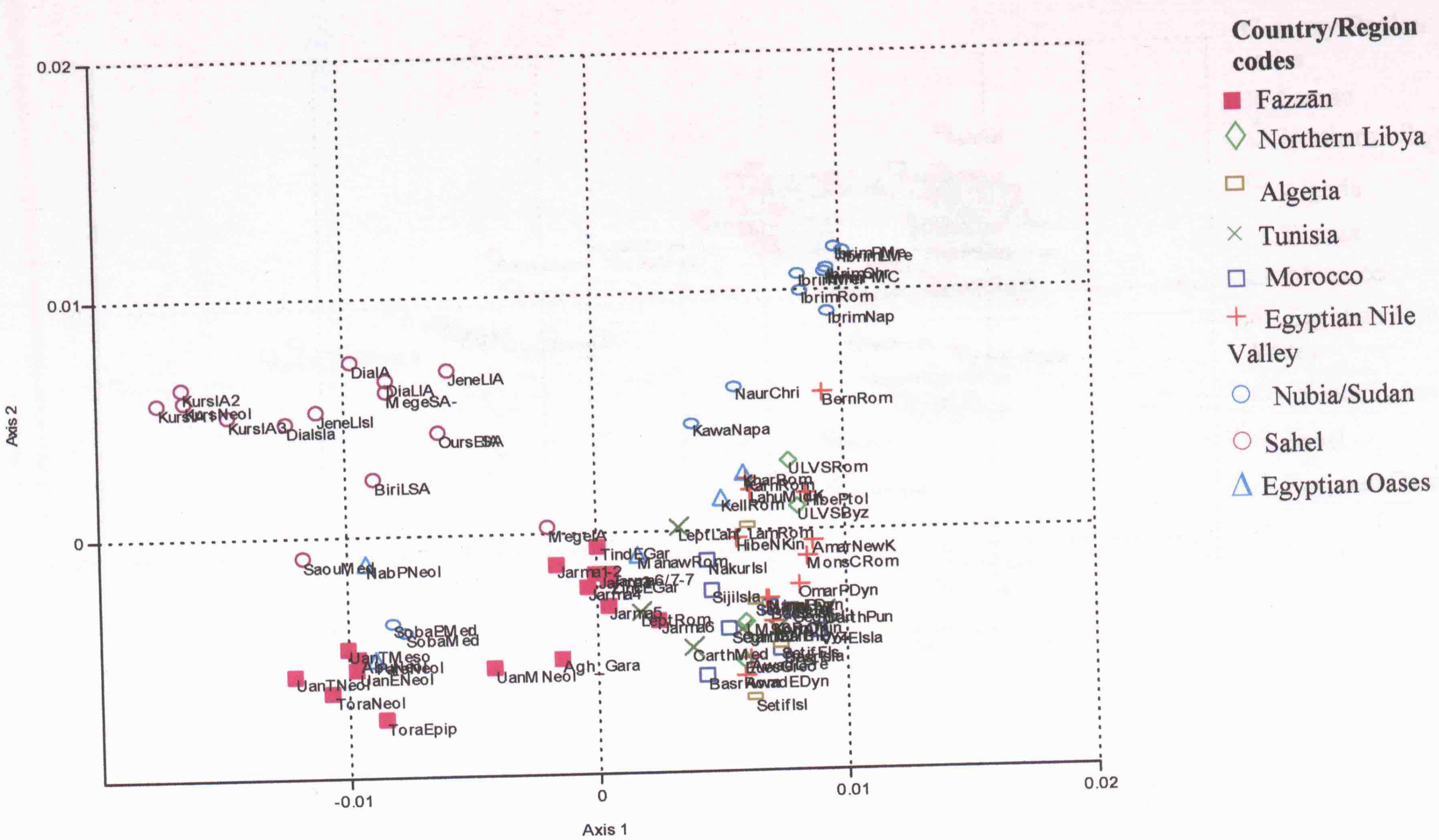


Figure 7.6 Correspondence Analysis plot showing all sites/phases and all taxa (charred and desiccated). Colour codes in the following plots relate to country/region.

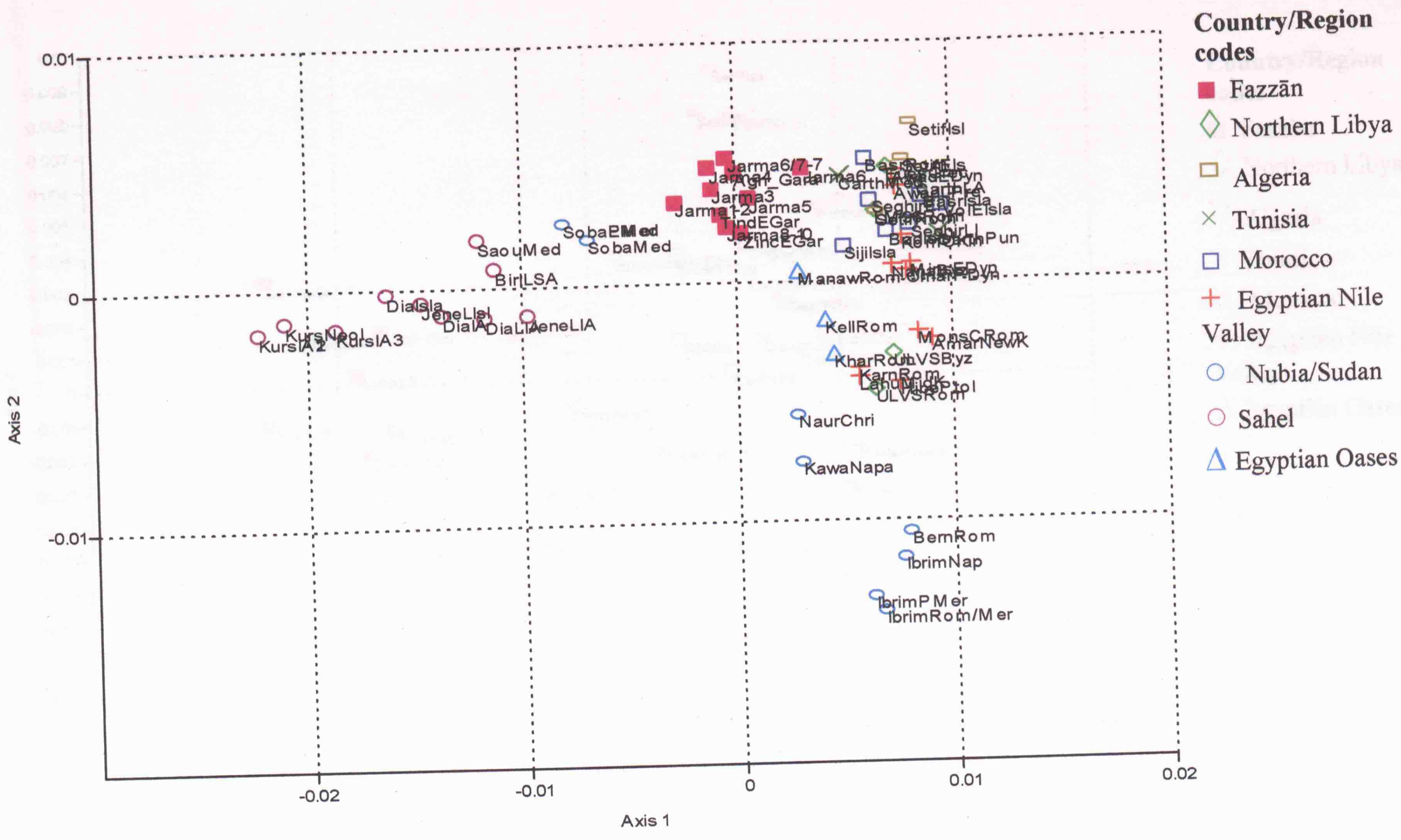


Figure 7.7 Correspondence Analysis plot of field crops and weeds from all agricultural period sites/phase (charred and desiccated)

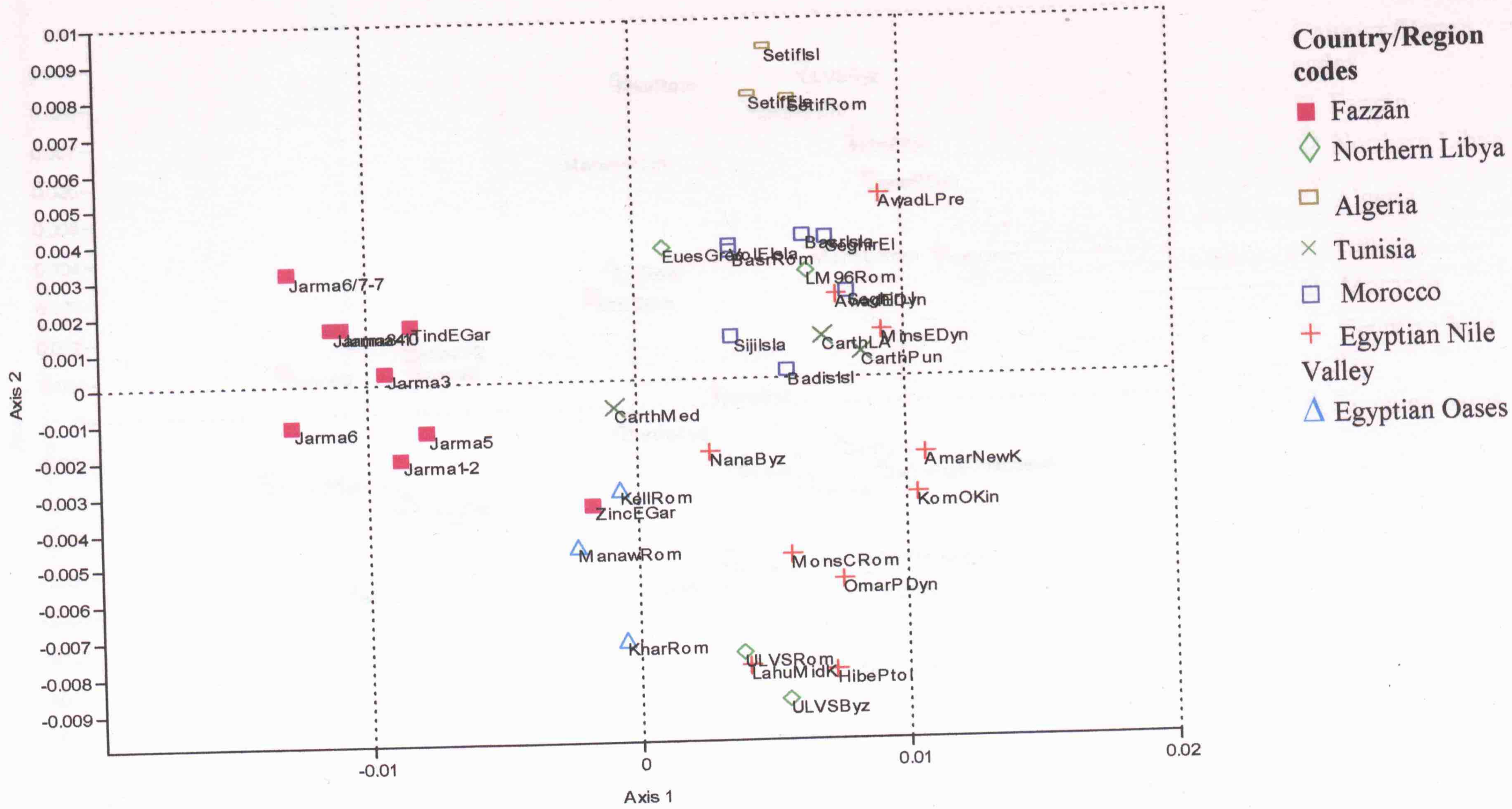


Figure 7.8 CA plot showing field crops and weeds from the Egyptian Nile Valley (excluding Qasr Ibrim), Oases and Maghreb/Fazzan sites/phases (charred and desiccated)

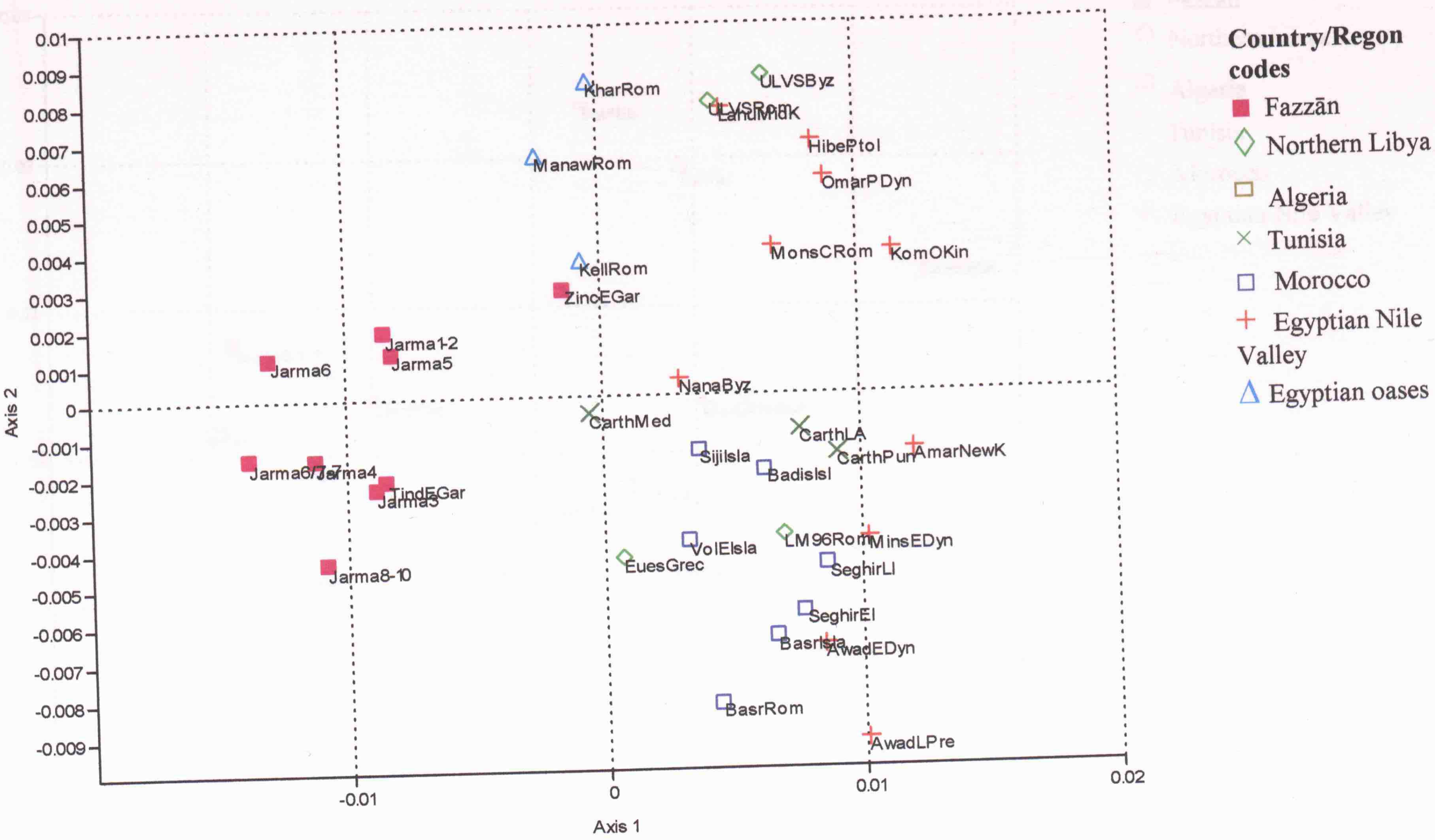


Figure 7.9 CA plot showing field crops and weeds from the Egyptian Nile Valley (Excluding Qasr Ibrim), oases, Maghreb/Fazzan sites, with Setif removed (charred and desiccated).

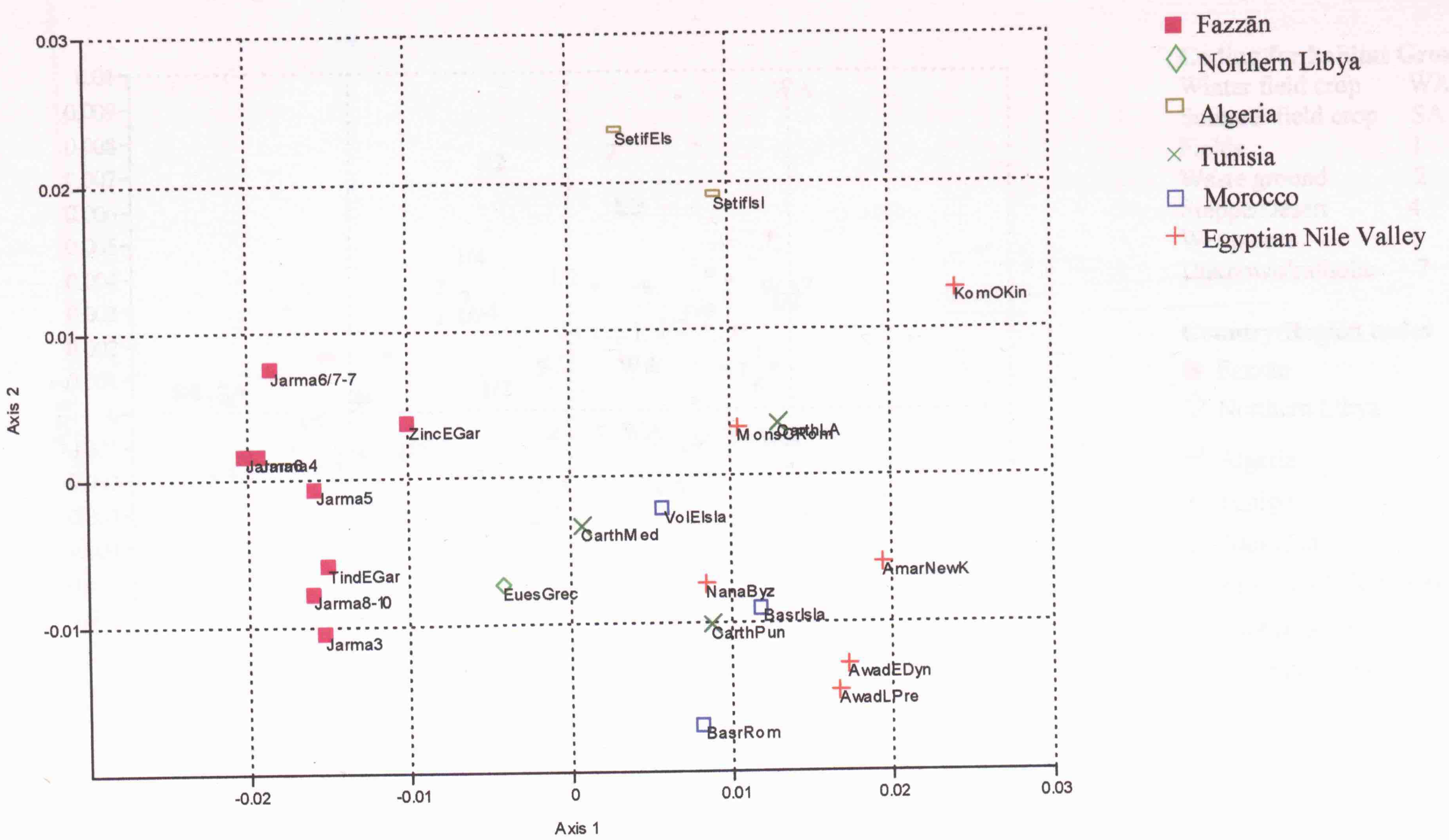


Figure 7.10 CA plot showing weeds only from the Egyptian Nile Valley (excluding Qasr Ibrim), oases and Maghreb/Fazzan sites/phases (charred and desiccated)

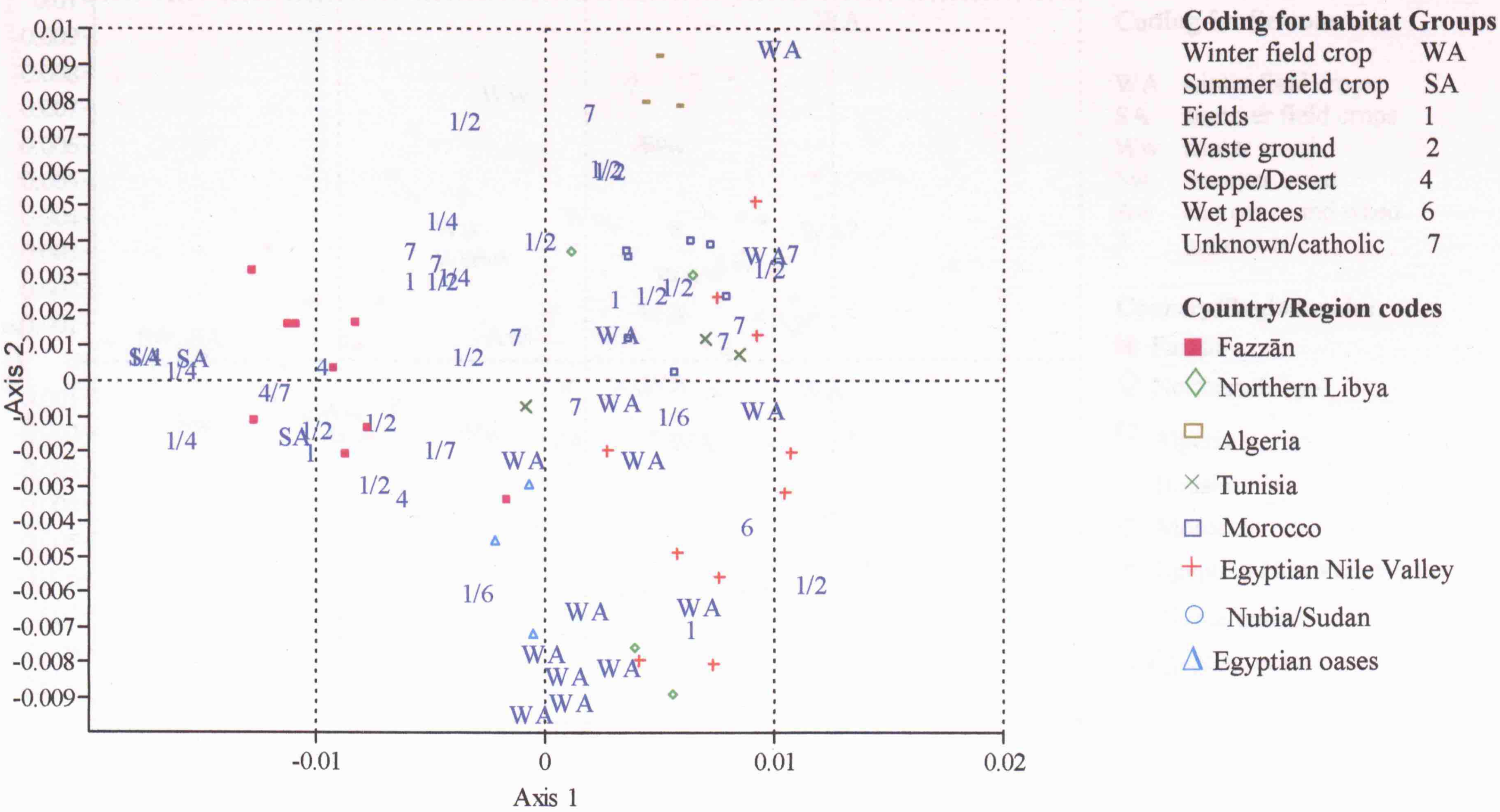


Figure 7.11 CA plot showing field crops and weeds from the Egyptian Nile Valley (excluding Qasr Ibrim), oases and Maghreb/Fazzan sites/phases (charred and desiccated) with habitat codes for species

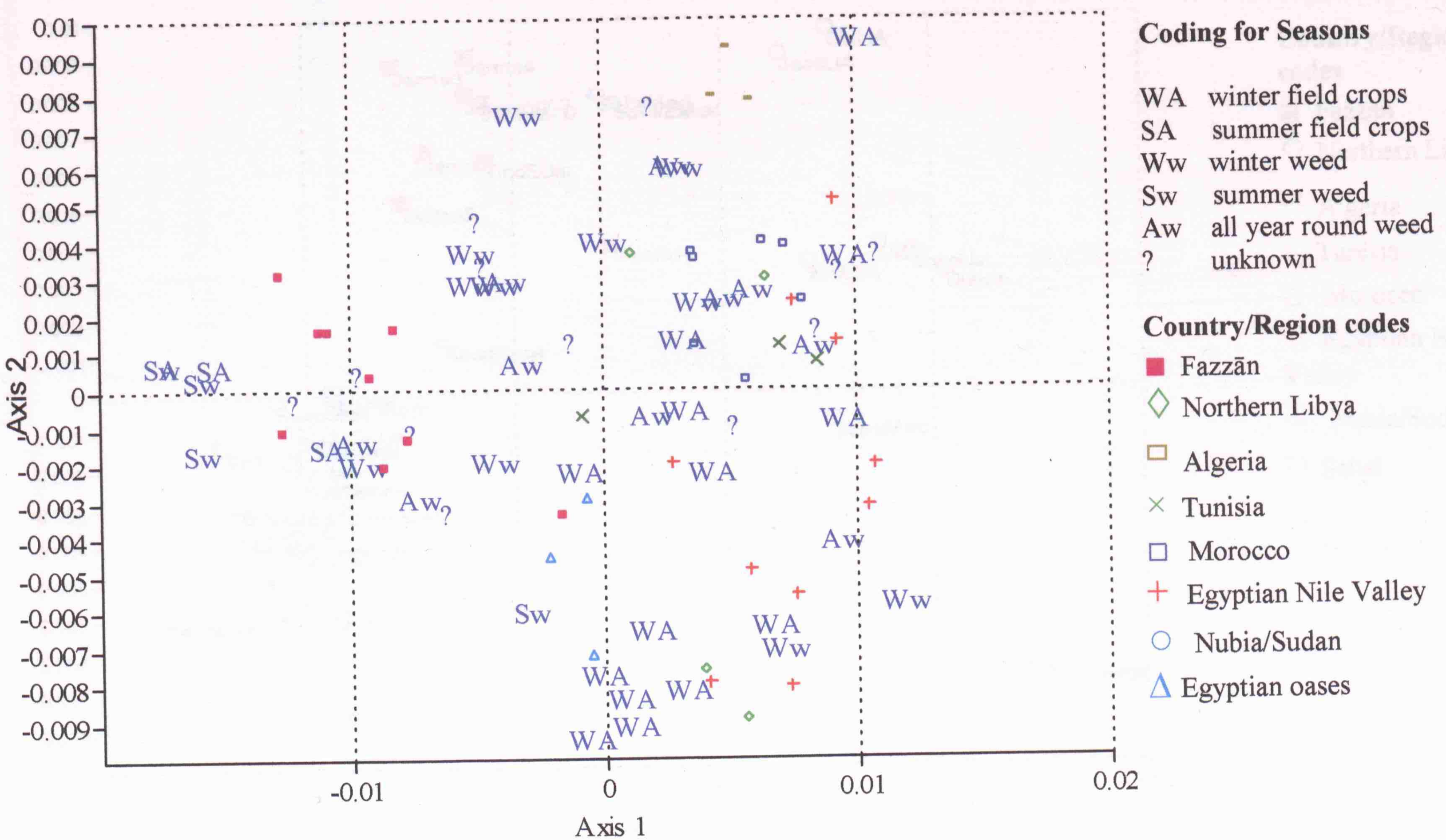


Figure 7.12 CA plot showing crops and weeds from Egyptian sites (excluding Qasr Ibrim), oases, and Maghreb/Fazzan sites/phases with habitat codes for season (charred and desiccated)

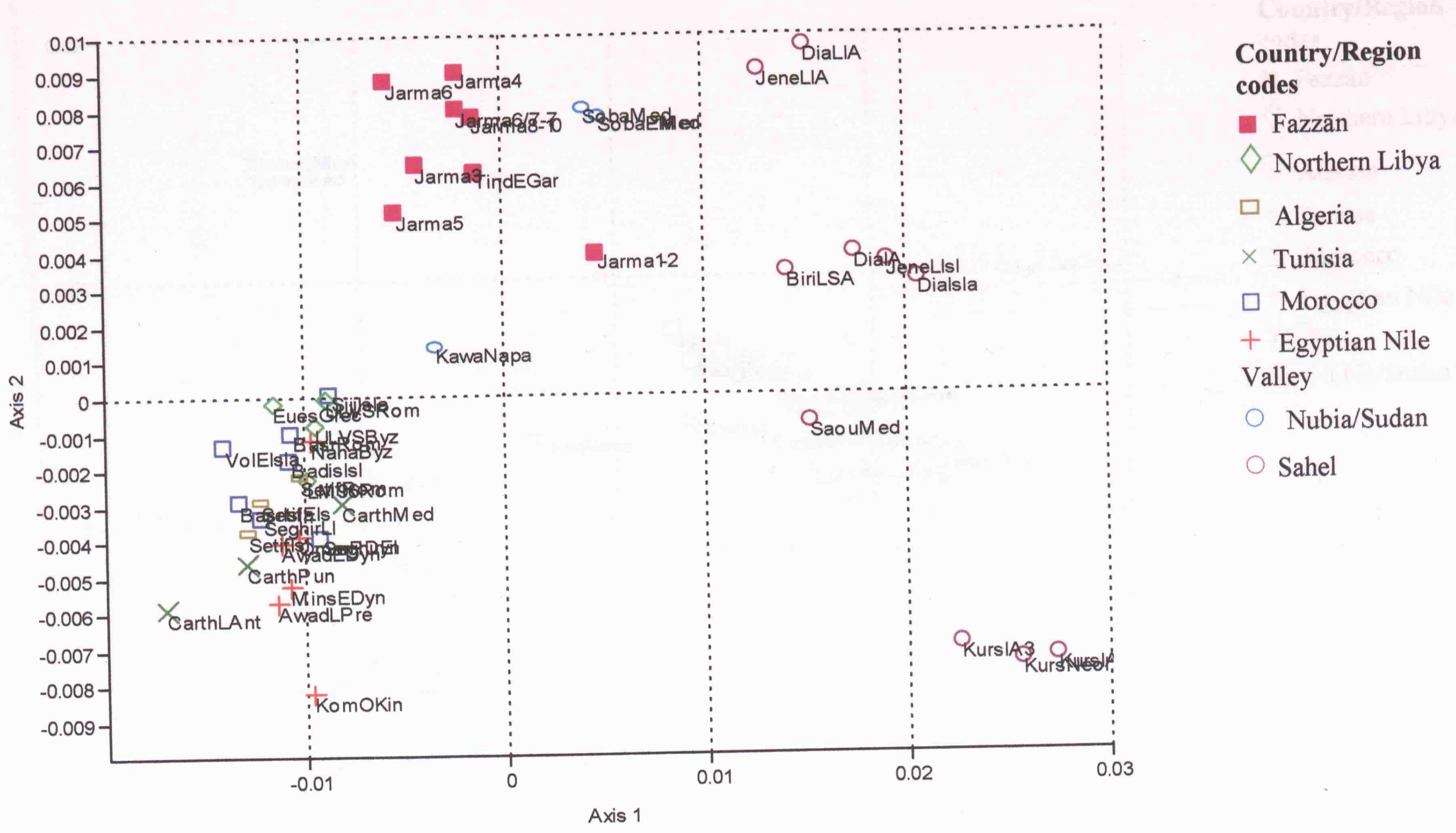


Figure 7.13 CA plot of all phases with rare taxa/small phases omitted using charred items only (field crops and weeds)

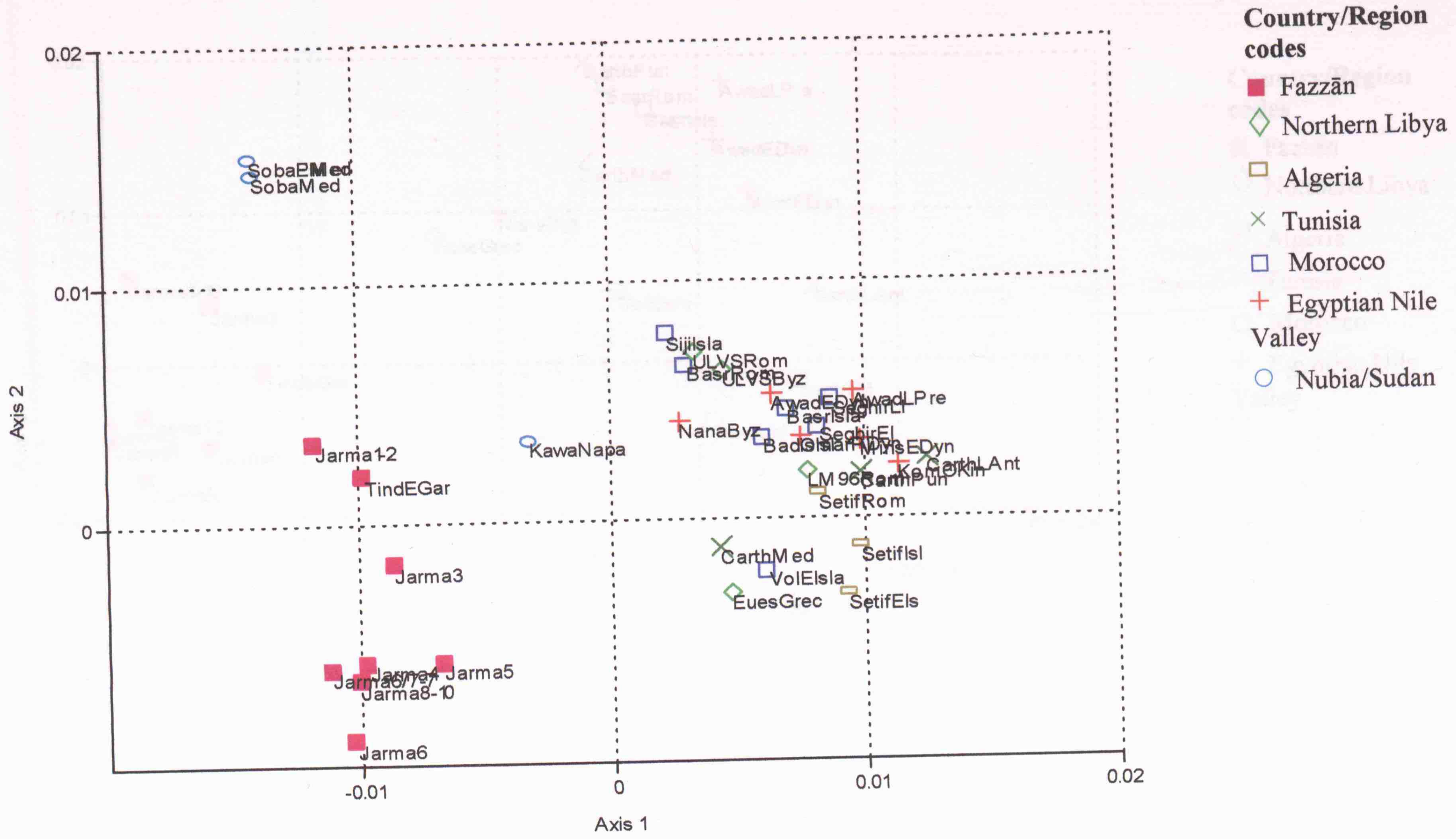


Figure 7.14 CA plot for all phases with Sahel sites removed (rare taxa and small phases removed) using charred items only (field crops and weeds)

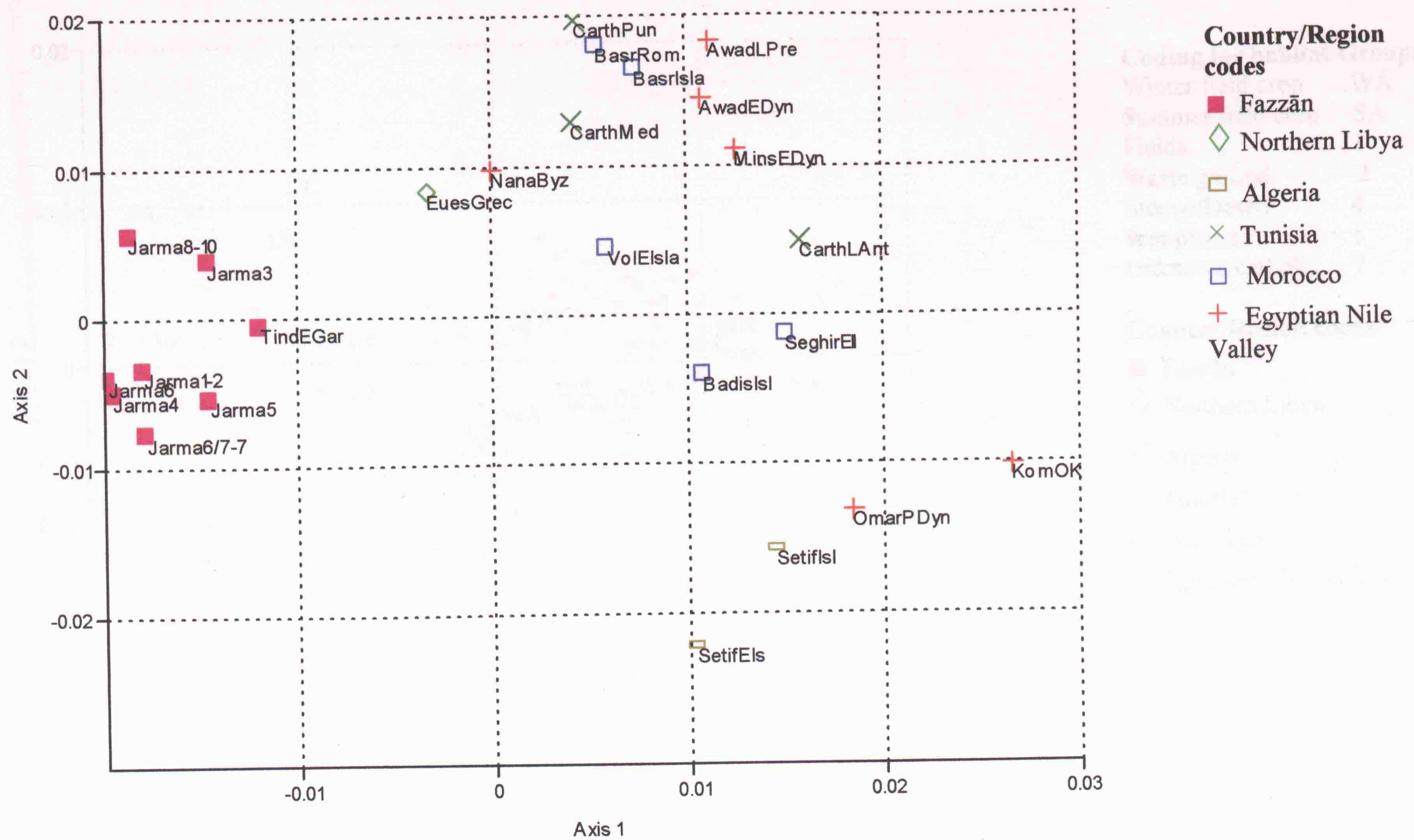


Figure 7.15 CA plot for all phases with Sahel/Nubian sites removed (rare taxa and small phases omitted), using charred weeds only

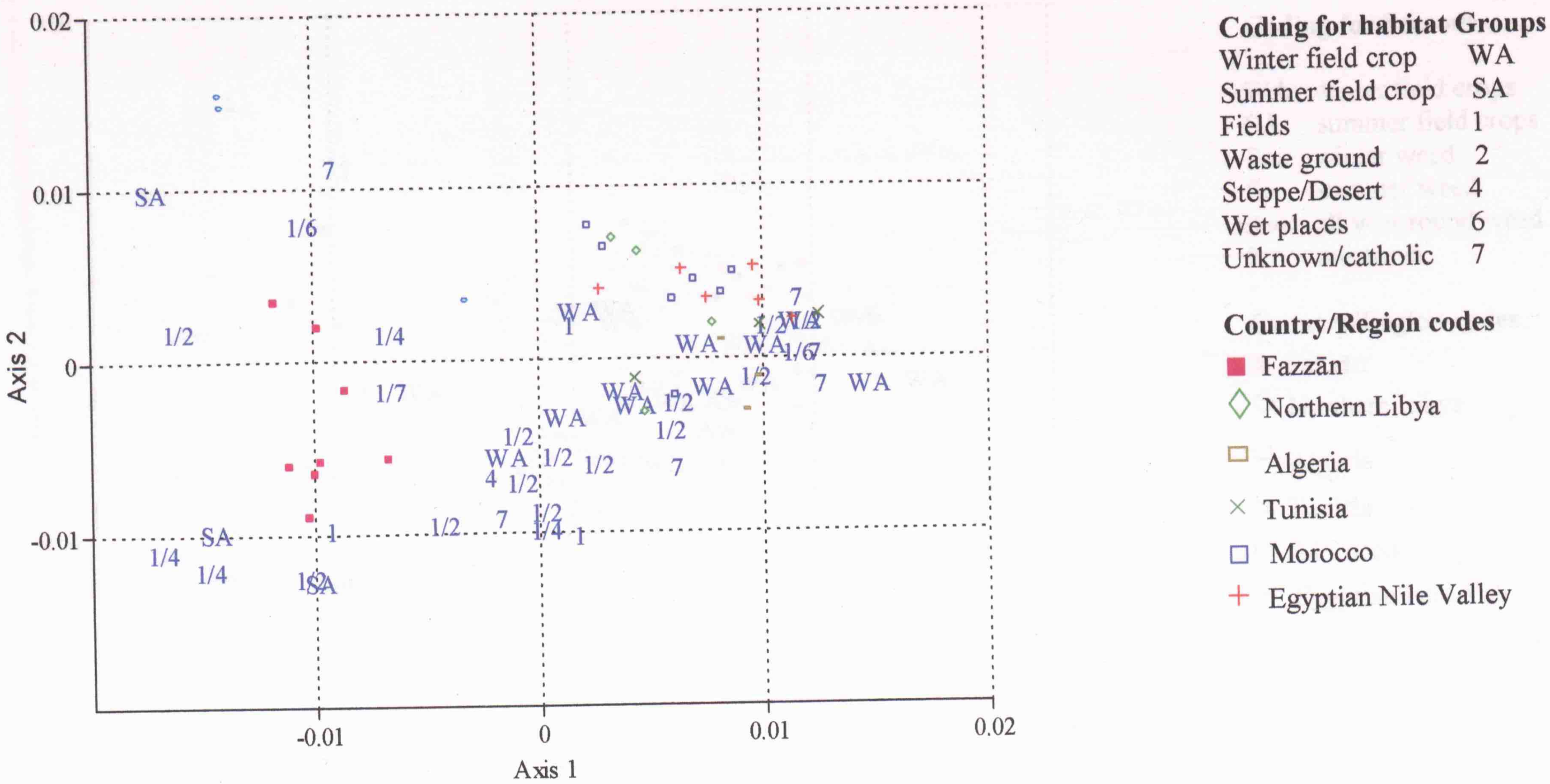


Figure 7.16 CA plot for all phases with Sahel/Nubian sites removed (rare taxa and small phases omitted), using charred field crop and weeds showing habitat codes

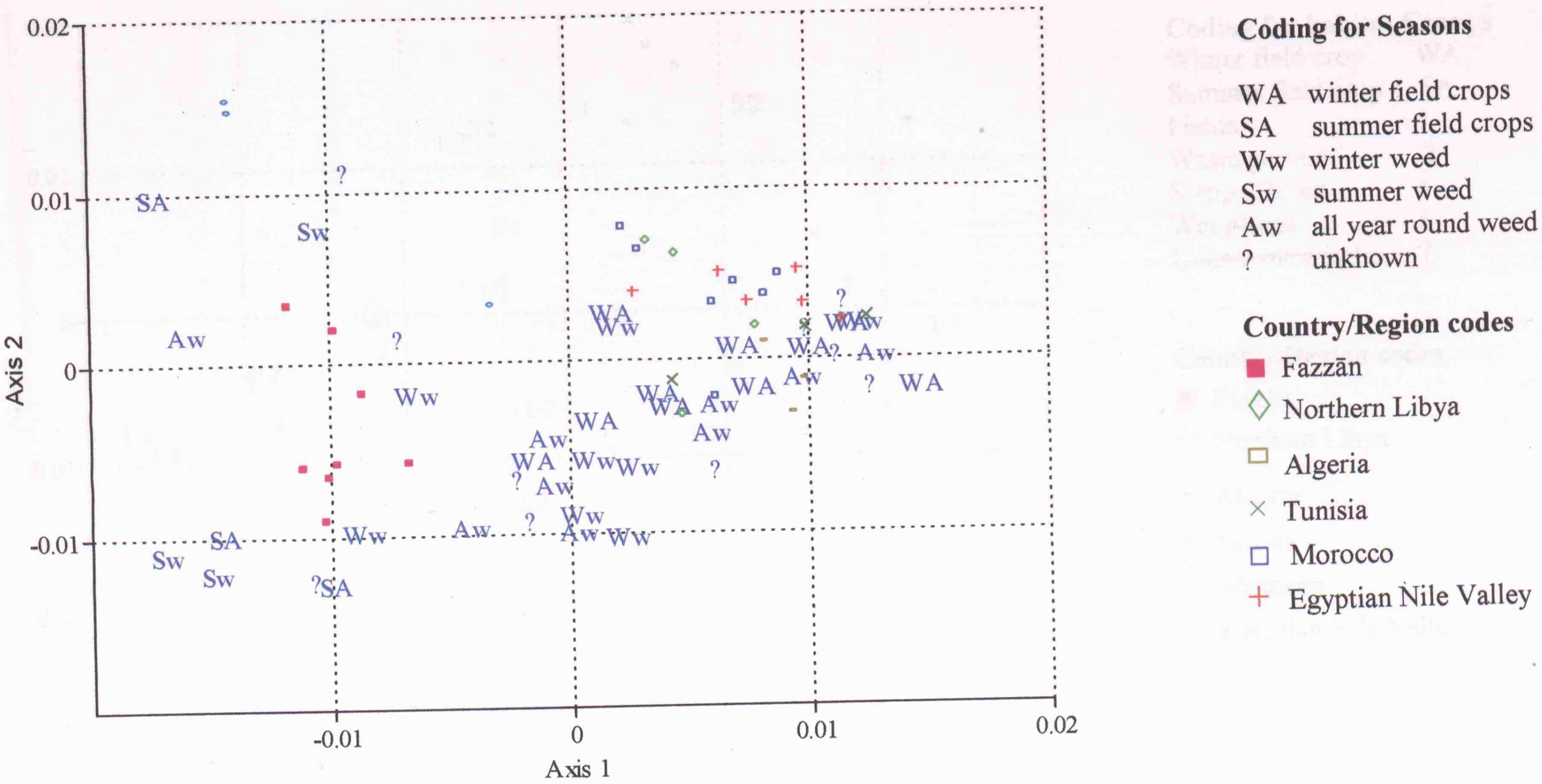


Figure 7.17 CA plot for all phases with Sahel/Nubian sites removed (rare taxa and small phases omitted), using charred field crops and weeds showing season codes

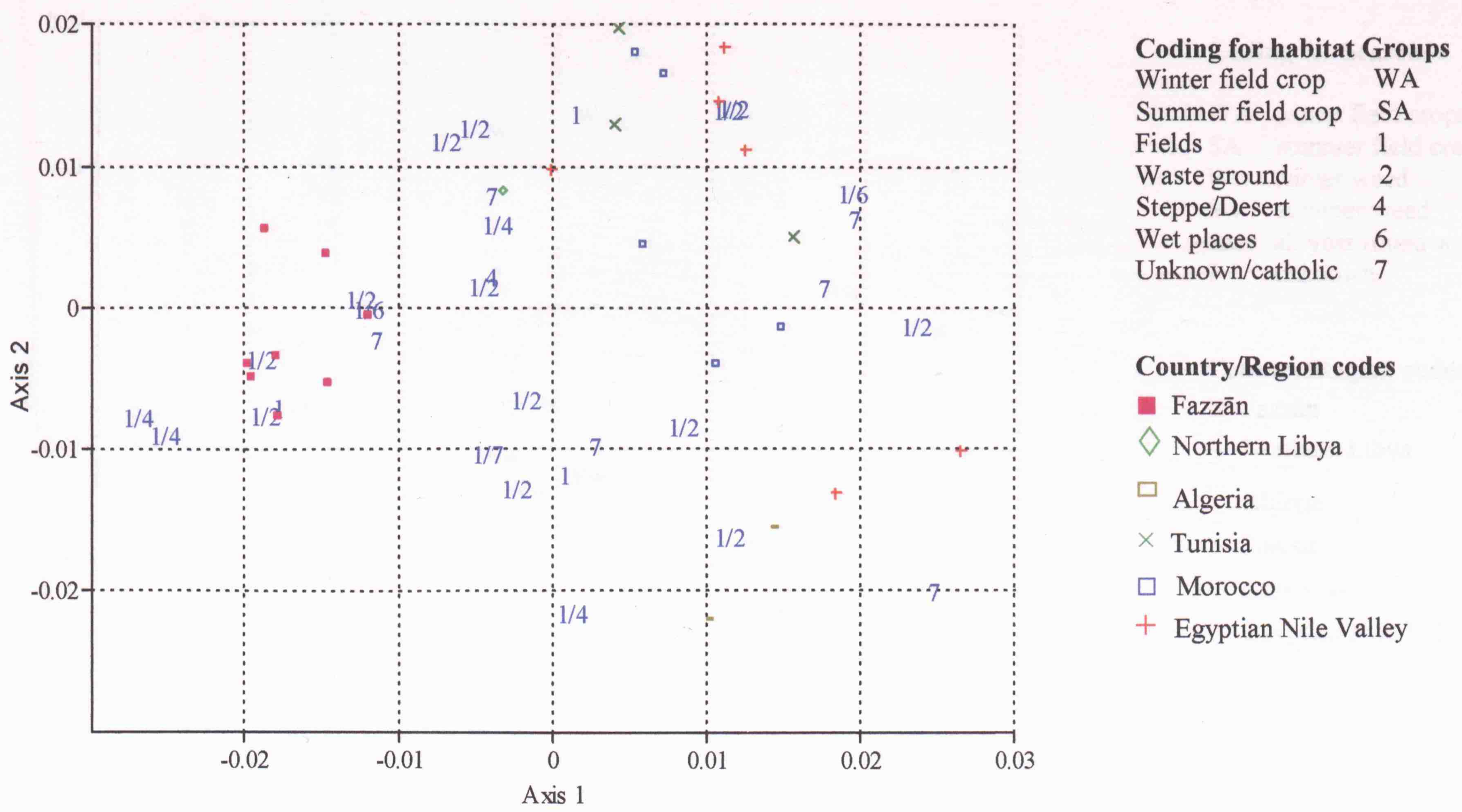


Figure 7.18 CA plot of charred weeds excluding Sahel/Nubian sites, showing habitat codes

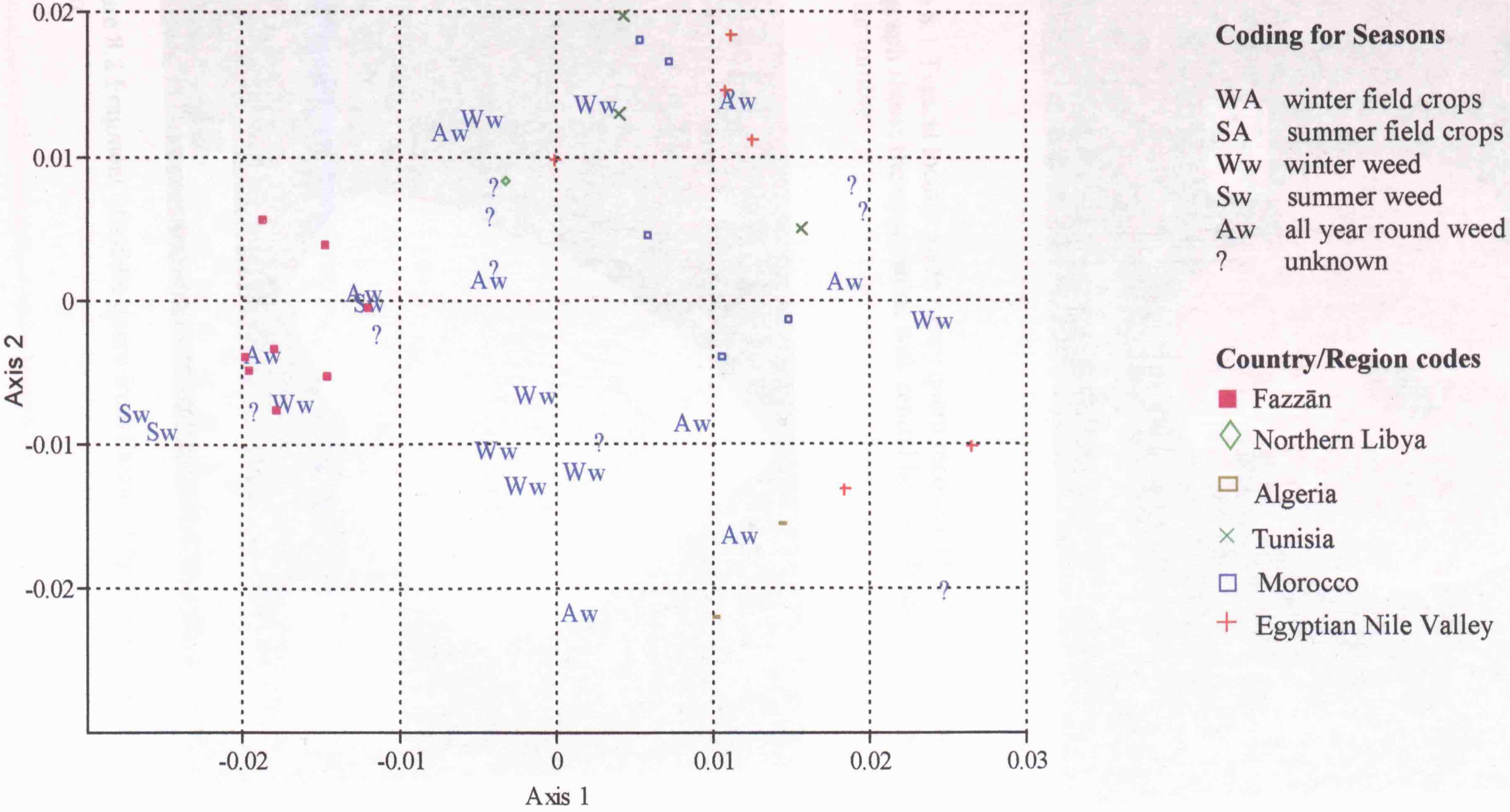


Figure 7.19 CA plot of charred weeds excluding Sahel/Nubian sites, showing season codes

Figure 8.1 Typical locally made rotary quern recovered from Jarma excavations. Photograph shows the upper stone with central hole for feeding grain and side hand holes for turning

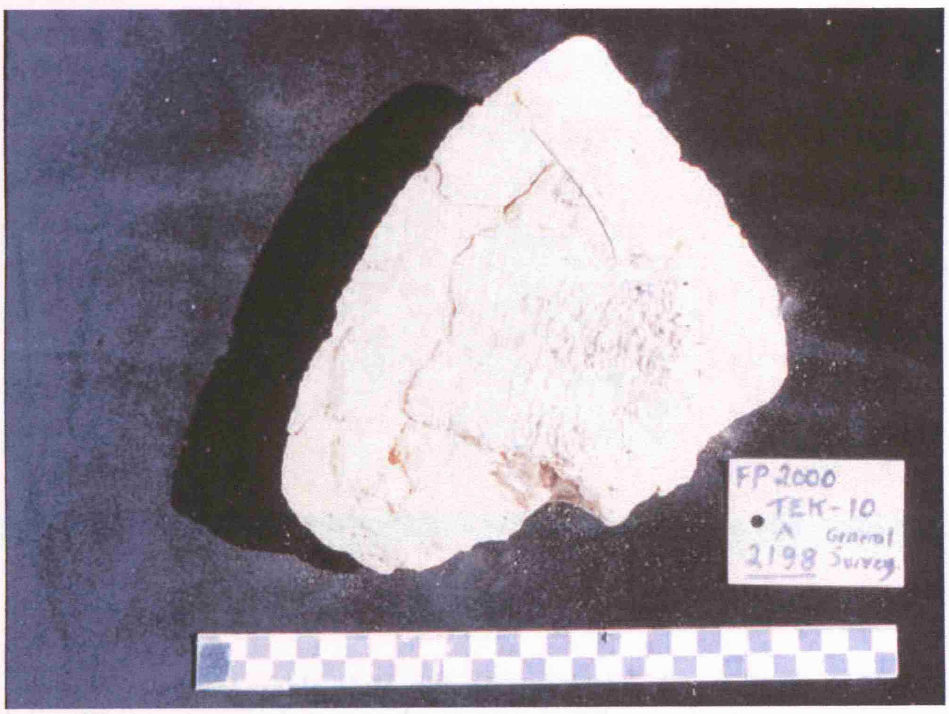


Figure 8.2 Fragment of saddle quern from Fazzan Project field survey, typical local form

Figure 9.1 Spreading manure on fallow plots, Jarma 2001.

Figure 9.2 Typical arable plots in the Jarma region. The irrigation channels have just been filled and water is being directed around the small plots in which winter cereals are being cultivated (February 2000).

APPENDICES

Appendix One: Details of samples included in the analysis from Jarma and Tinda B

Sample	Context	Vol. (litres)	Processing method	Phase	Feature type	Excavation Notes
01S/003	061S	5	flotation	1 early	spread	Floor in Rm. 2/3
01S/004	061N	2	flotation	1 early	spread	Floor in Rm. 2/3
01S/022	52	2	flotation	1 mid	spread	Floor surface, Rm 4
03CF/046	219	5	flotation	3 late	spread - ext	Phase II fill S of 207
02CF/047	81	2	flotation	2 late	spread - ext	Compacted deposits below floor of Rms. 8/11, Ex.2.2
1/2S/048	115	5	flotation	1/2	spread	Surface below wall 36. Rm 4
03F/102	283	10	flotation	3 early	spread/floor	Large room, black layer below wall 301 = 310
04S/104	365	10	flotation	4 early	spread	Phase IV floor surface. Rm 4.1
03PF/105	358	10	flotation	3 late	pit fill	Fill of Pit 21
03PF/106	375	10	flotation	3 early	pit fill	Ashy fill of pit 24
04PF/107	376	4	flotation	4 late	pit fill	Small pit 25 fill
03RF/108	389	10	flotation	3 mid	room/bin fill	Bin bordered by walls [185], [325], [326], [327]
03RF/117	402		flotation	3 mid	spread/room fill	Fill/subsurface in rm. 3.3 north
04RF/121	391		flotation	4 late	spread/room fill	Significant deposit of burnt material Rm. 4.1, slumps in direction of well.
04I/128	468	10	flotation	4 early	fire instillation	Fire patch in [469], below [445]
04CF/129	469N	10	flotation	4 mid	spread - ext	Courtyard fill below [445]
03PF/303	554	4	dry	3-Early	Pit fill (fire)	Fill of [553] - a small circular fire pit southwest corner phase 3
05PF/361	535	10	flotation	5 late	pit fill	Dark grey/blue fill
05F/363	542	4.5	flotation	5 late	spread/floor	Dark blue/grey ash/gypsum spread above [541] below [365]
03S/364	586 NE	10	flotation	3 early	spread	Ashy spread (possible floor) below [544] (replaces [568b])
05F/366	542	10	flotation	5-Late	spread/floor	Dark blue/grey ash/gypsum spread above [541] below [365]
03F/367	586 SE	10	flotation	3 early	spread/floor	Ashy spread (possible floor) below [544]

						(replaces [568b])
05S/382	607	10	flotation	5 mid	spread	Floor surface below [484]
04F/383	644	10	flotation	4 early	spread/floor	Burnt deposit sat on [642], south west corner
05S/385	607 sq2 sp1	10	flotation	5 mid	spread	Floor surface below [484]
05F/386	652	10	flotation	5 mid	spread - ext?	Burnt layer cut in [651], ext. Rm. 4.1
05S/387	642 Sq 4 Sp1	10	flotation	5 mid	spread	Mixed deposit from Q4 of SW Room
05F/389	652	3.5	flotation	5 mid	spread - ext?	Burnt layer cut in [651], ext. Rm. 4.1
05S/390	607 Sq5 Sp 1	10	flotation	5 mid	spread	Floor surface below [484]
05S/393	654	10	flotation	5 mid	spread	Possible surface layer, or fill in cut [649]
05PF/395	655	10	flotation	5-Mid	spread	Brown layer below [651], with possible burnt area fill of cut [677]
05S/398	607 Sq2 Sp 1	10	flotation	5 mid	spread	Floor surface below [484]
06F/400	661	10	flotation	6-Late	spread/floor	Soil Layer in southern area, Room 6.1
05RF/401	611	10	flotation	5 early	spread/room fill	Layer below [608] Rm 4.1 above Rm 6.1
06F/402	661	15	flotation	6 late	spread/floor	Soil Layer in southern area, Room 6.3
06F/405	665	10	flotation	6-Early	spread/floor	Soil layer in southern area, Room 6.3
06F/407	674	10	flotation	6 mid	spread/floor	Dump deposits intermixed lenses below [670]
05S/408	607	10	flotation	5 mid	spread	Floor surface below [484]
05S/410	607 Gr9 Sp1	6	flotation	5 mid	spread	Floor surface below [484]
05S/411	607 Gr1 Sq2	10	flotation	5-Mid	spread	Floor surface below [484]
06PF/414	678	10	flotation	6-Mid	pit fill	Fill of cut [679]

05S/415	607 Gr6Sp2	10	flotation	5-mid	spread	Floor surface below [484]
04I/511	718	4.5	flotation	4 late	fire instillation	
06F/513	739	10	flotation	6 late	spread/floor	soil layer under 673, Ex 6.1
06PF/517	756	10	flotation	6 late	Pit fill (fire)	fill of pit/hearth feature 755
06RF/520	764	10	flotation	6 late	spread/room fill	Room fill in west half of Rm 6.2 = 738
06RF/521	764 lower spit	10	flotation	6 late	spread/room fill	Room fill in west half of Rm 6.2 = 738
06F/534	799	8	flotation	6 mid	spread/floor	Burnt deposits within 789
07CF/549	846	10	flotation	7 late	spread - ext	Courtyard fill, surfaces S of 844
6/7PF551	837	10	flotation	6/7	pit fill	Fill of pit cut 836
07F/553	868	10	flotation	7 late	spread/floor	
06IF/554	871	9	flotation	6 early	spread/fire	Room 6.2, within phase 6 house, storage area?
6/7PF569	909	6	flotation	6/7	pit fill	Gypsum flecked deposits under 906? - pit 67
08PF/571	914	10	flotation	8-late	pit fill	Fill of pit 915
10PF/583	4033	10	flotation	10 late	pit fill	
08PF/584	943	10	flotation	8-late	pit fill	Fill of pit cut 944. Filled and sealed by brick packing
10PF/585	4035	10	flotation	10 late	pit fill	Pit fillin temple complex - 3rd C BC bead
09F/589	899	10	flotation	9 early	spread/floor	Fill S of 898
07S/592	925	10	flotation	7 late	spread	Surface / sub-surface fill N of wall 761
09S/594	940	10	flotation	9 early	spread	Compacted surface below 862 at W of 666
09PF/596	962	10	flotation	9-Early	pit fill	Fill of possible pit 73 W of 666, E Sector
10PF/598	955	10	flotation	10 late	pit fill	Fill of pit 71 cut 954
09F/599	951	10	flotation	9-Early	spread/floor	Fill S of wall 890, below 589
06PH/615	777	2.5	flotation	6-mid	post-hole	seen in section only
TINDA B	-	2.6	dry	-	-	deposit of burnt grain

Appendix Two: The Desiccated Plant Remains from Jarma (samples with more than 30 items only), phases 1 to 3

	01S/003	01S/004	01S/022	1/2S/048	02CF/047	03CF/046	03S/364	03F/367
Cereal Grain								
Hordeum vulgare L. (Barley, hulled grain)	9	1	-	-	2	-	-	-
Hordeum vulgare L. (Barley grain)	-	-	1	-	-	-	-	-
Hordeum vulgare L. (Barley, hulled grain lemma/palea only)	-	-	-	-	-	4	-	-
Hordeum vulgare L. (Barley, hulled six-row lemma base/grain)	-	-	-	-	-	1	-	-
Hordeum vulgare L. (Barley, six-row grain/lemma base)	-	-	-	-	-	-	-	-
Sorghum bicolor (L.) Moench (Sorghum grain)	-	-	-	-	-	3	-	-
cf. Sorghum bicolor (L.) Moench (cf. Sorghum grain)	1	-	-	-	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown (Pearl millet grain)	-	4	2	7	3	7	-	-
cf. *Pennisetum glaucum* (Linn.) R. Brown	4	-	-	-	-	-	-	-
Various cereals (Indeterminate grain)	-	-	-	-	-	-	-	-
Cereal Chaff								
Triticum aestivum L. (Bread wheat type, rachis)	47	22	-	6	2	21	1	-
Triticum aestivum L. (Bread wheat type, basal rachis)	-	3	-	-	-	1	-	-
Triticum aestivum L. (Bread wheat type, near terminal rachis)	3	2	-	2	1	-	-	-
Triticum cf. aestivum L. (cf. Bread wheat type, rachis)	-	-	-	2	2	5	1	-
Triticum durum Desf. (Hard wheat rachis)	-	-	-	-	-	2	-	-
Triticum cf *durum* Desf. (cf. Hard wheat rachis)	1	-	1	-	-	-	-	-
Triticum aestivum/durum (Bread/Hard wheat rachis)	12	36	3	10	3	7	-	-
Triticum aestivum/durum (Bread/Hard wheat basal rachis)	-	-	-	-	-	2	1	-
Triticum sp. (Wheat, rachis internode)	7	4	1	1	-	-	-	-
Hordeum vulgare L. (Barley, dense-eared, stalked rachis)	-	-	-	5	6	-	-	-
Hordeum vulgare L. (Barley, dense-eared rachis)	15	2	-	16	2	-	-	-
Hordeum vulgare L. (Barley, six row rachis)	-	-	-	-	-	13	2	-
Hordeum vulgare L. (Barley, six-row basal rachis)	-	-	-	-	-	-	-	-
Hordeum vulgare L. (Barley, rachis)	8	7	-	29	7	7	6	1
cf. Hordeum vulgare L.(cf Barley rachis)	-	-	-	-	-	-	-	-
Sorghum bicolor var *durra* (Durra sorghum, spikelet)	23	5	-	-	3	166	-	-
Sorghum bicolor (L.) Moench (Sorghum (cultiv) glume base)	2	-	-	-	-	31	-	-

	01S/003	01S/004	01S/022	1/2S/048	02CF/047	03CF/046	03S/364	03F/367
Sorghum bicolor (L.) Moench (Sorghum glume frags)	11	-	-	-	+	++	-	-
cf. Sorghum bicolor (L.) Moench (Sorghum immature spikelet)	-	-	-	-	-	23	-	-
Pennisetum glaucum (Linn.) R. Brown (Pearl millet ear segment)	-	-	-	1	-	1	-	-
Pennisetum glaucum (Linn.) R. Brown (Pearl millet involucre)	84	16	20	162	118	116	-	-
Pennisetum sp. (involucre)	3	10	3	45	54	34	-	-
cf. *Pennisetum* sp. (involucre rachis and rachilla)	-	6	-	-	-	17	-	-
Cerealia indet (indeterminate rachis internode)	16	20	-	15	2	6	3	-
Cerealia indet (indeterminate basal rachis)	1	3	-	1	-	-	-	-
Cerealia indet (culm nodes, large)	2	7	1	-	-	3	-	-
Cerealia indet (Culm nodes small)	-	-	-	4	2	6	-	-
Chaff fragments not used in numerical analysis								
Triticum aestivum L. (Bread wheat type glume tip)	-	-	-	-	-	-	-	-
Triticum aestivum/durum (Bread/Hard wheat glume frags)	+	++++	-	++	++	-	-	-
Triticum dicoccum/monococcum (Bread/Hard wheat glume base)	-	-	-	-	-	-	-	-
Triticum sp. (Wheat rachilla)	7	40	-	6	11	7	-	-
Hordeum vulgare L. (Barley lemma frags)	+++	+	-	++	++	+	1	-
Triticum/Hordeum sp. (Wheat/Barley awn frags)	5	40	-	20	13	21	1	++
Cerealia indet (straw lengths)	-	-	-	-	-	-	-	-
Cerealia indet (detached embryo)	-	-	-	-	-	-	-	7
Cerealia indet (bran 'beards')	12	3	-	-	10	-	-	-
Cerealia indet (bran frags)	-	-	-	-	++	-	-	-
Cerealia indet (light chaff general)	-	-	-	-	+	+	-	-
Pulses								
cf. *Vicia* sp. (hila)	5	-	-	-	-	-	-	-
cf. *Pisum* sp. (,hila)	2	-	-	-	-	-	-	-
Leguminoseae (hila)	-	1	1	-	3	-	-	-
Leguminoseae (seed)	-	-	-	1	-	-	-	-
Leguminoseae (testa frags)	-	1	-	-	-	-	-	-
Leguminoseae (pod frag)	-	-	-	-	++	1	-	-

	01S/003	01S/004	01S/022	1/2S/048	02CF/047	03CF/046	03S/364	03F/367
Fruit/Spices etc								
Ficus carica L. (Fig)	30	-	1	7	1	10	-	-
Vitis vinifera L. (Grape seed)	-	-	-	-	-	-	-	1
cf. *Vitis vinifera* L. (Grape seed)	1	-	-	-	-	-	-	-
Phoenix dactylifera L. (Date stone)	3	5	2	3	1	1	1	11
Phoenix dactylifera L. (Date perianth)	18	1	1	4	2	1	-	1
Phoenix dactylifera L. (Date, male flower)	1	1	-	-	-	-	-	-
Phoenix dactylifera L. (Date rachilla)	-	-	-	-	-	10	-	-
Phoenix dactylifera L. (Date embryo)								
Citrullus lanatus (Thunb.) Mats. & Nakai (Water melon seed)	2	-	-	-	-	-	-	-
Cucurbita sp. (Pumpkin/Squash etc. seed coat)	1	-	-	-	-	1	-	-
Cucumis sp. (Melon/Cucumber seed)	3	4	-	-	-	1	-	-
cf Cucumis sp. (Melon/Cucumber seed)	-	-	-	-	-	1	-	-
Cucumis melo L. (Melon seed)	-	1	-	-	-	-	-	-
Cucurbitaceae (seed fragment)	4	1	1	1	4	7	-	-
Linum usitatissimum L. (Flax, capsule fragments)	-	-	1	19	3	3	-	-
Linum usitatissimum L. (Flax, capsule tips)	-	2	-	6	-	-	-	-
Linum usitatissimum L. (Flax seeds)	-	-	1	-	-	-	-	-
Capsicum sp. (Sweet pepper/Chili seed)	56	15	2	1	4	11	-	-
Nigella sativa L. (Black cumin)	1	-	-	-	-	-	-	-
Cuminum cyminum L. (cf. Cumin)	-	-	-	-	1	-	-	-
Weeds								
Amaranthaceae								
Amaranthus sp.	-	-	-	-	-	1	-	-
Apiaceae								
Apiaceae large	-	-	-	-	-	-	-	-
Asteraceae								
Calendula sp.	-	-	-	-	-	1	-	-
Asteraceae indet (small seeded)	-	-	-	-	-	1	-	-

	01S/003	01S/004	01S/022	1/2S/048	02CF/047	03CF/046	03S/364	03F/367
Boraginaceae								
Heliotropium cf. *europaeum* L.	-	-	-	1	-	-	-	-
Brassicaceae								
Coronopus sp.	1	-	-	-	-	-	-	-
cf. *Raphanus raphanistrum* L. capsule frag.	-	-	-	1	-	-	-	-
Brassicaceae indet (small seeded)	-	-	-	-	-	-	-	-
Caryophyllaceae								
Silene cf. gallica L.	1	1	2	-	-	-	-	-
Caryophyllaceae small seeded	-	-	2	-	-	-	-	-
Chenopodiaceae								
Chenopodiaceae small seeded	-	1	-	-	-	-	-	-
Chenopodium murale L.	-	-	-	-	-	2	-	-
Suaeda sp.	1	-			-			
Cyperaceae								
cf. Carex sp.	-	-	-	-	-	-	-	-
Cladium mariscus (L.) R. Br.	9	3	-	1	-	1	-	-
Euphorbiaceae								
Euphorbia peplus L.	1	-	-	-	-	1	-	-
Fabaceae								
Alhagi sp. pod	-	-	-	-	-	-	-	-
Alhagi type seed	-	-	-	-	1	-	-	-
Fabaceae indet	-	-	-	-	1	-	-	-
Fabaceae large	1	-	-	5	1	-	-	-
Fabaceae small	-	-	-	2	-	-	-	-
Fumariaceae								
Fumaria sp.	1	1	2	-	-	-	-	-
Liliaceae								
Asphodelus cf. *tenuifolius* Cav.	-	1	-	-	-	-	-	-
Malvaceae								
Malva sp.	-	-	-	-	-	-	-	-

	01S/003	01S/004	01S/022	1/2S/048	02CF/047	03CF/046	03S/364	03F/367
Poaceae								
cf. *Digitaria* sp. glumes	-	-	-	-	-	-	-	-
Cynodon sp. lemma/palea	-	-	1	-	3	3	-	-
Cynodon sp.	2	9	5	-	4	9	-	-
Cynodon B type	5	1	-	2	-	-	-	-
Lolium/Festuca type small seeded	-	-	-	2	-	-	-	2
Festuca pratensis gp (*F.* cf. *arundinaceae)*	-	-	-	-	-	3	-	3
Lolium temulentum L. type	-	-	-	1	-	-	-	1
Lolium/Festuca type large seeded	2	2	1	-	1	-	-	6
Lolium/Festuca type large seeded, lemma/palea	-	-	-	1	-	-	-	1
Phalaris sp. caryopsis and glume	-	10	5	-	-	-	-	-
Phalaris sp. glumes	-	-	-	-	-	-	-	-
Setaria/Brachiaria type	2	1	-	-	-	-	3	1
Setaria/Brachiaria type lemma/palea	-	1	-	-	-	-	-	-
Setaria/Brachiaria small type	-	-	-	-	-	-	-	-
Brachiaria type	-	-	-	-	-	-	-	-
Poaceae indeterminate, large seeded	-	5	1	-	-	2	-	-
Poaceae indeterminate, small seeded	-	-	-	1	1	1	-	-
Poaceae indeterminate, chaff frags.	-	-	-	-	-	-	-	-
Polygonaceae								
Emex spinosa	-	-	-	-	-	-	-	-
Portulaceae								
Portulaca oleracea L.	-	18	22	6	35	93	-	-
cf. Portulaca oleracea L.	118	-	3	-	-	34	-	-
Primulaceae								
Anagallis arvensis L. type	1	2	-	-	-	1	-	-
Rutaceae								
Haplophyllum sp. seed capsule segment	-	-	3	-	-	-	-	-
Scrophulariaceae								
Linaria sp.	-	-	-	-	-	-	1	-

	01S/003	01S/004	01S/022	1/2S/048	02CF/047	03CF/046	03S/364	03F/367
Wild Fruits/Trees								
Tamarix sp., leaflets	116	294	670	36	33	332	-	-
Tamarix sp. flower	-	1	-	-	-	-	-	-
cf. Mimosaceae thorn	-	-	-	-	-	40	-	-
Indeterminate/Unidentified seeds								
Jarma Type 5	-	-	-	-	-	-	-	-
Other' seed	-	-	-	1	-	-	-	-
indeterminate seed	3	1	-	3	1	3	-	4
Unidentified Non-Seed Items								
cf. Monocotyledon epidermis	-	-	-	5	4	-	-	-
Myriophullym/Zylophyllum sp. stem frags	21	-	16	1	24	33	30	-
Type P leaves, small	-	-	-	13	1	23	-	-
Type P leaves, large	-	-	-	1	-	15	-	-
Other varied leaves	-	-	-	4	5	-	-	-
Large thorns	-	-	-	-	-	-	-	-
Indet bud/flower	4	1	-	4	2	5	-	-
Indet testa fragment	-	-	-	1	-	-	-	-
Total	689	616	775	466	377	1155	51	39

Appendix 2 cont.: The Desiccated Plant Remains from Jarma (samples with more than 30 items only). Phases 1 to 3

	04PF/107	05F/366	05F/389	05RF/401
Cereal Grain				
Hordeum vulgare L. (Barley, hulled grain)	-	-	-	-
Hordeum vulgare L. (Barley grain)	-	-	-	-
Hordeum vulgare L. (Barley, hulled grain lemma/palea only)	-	-	-	-
Hordeum vulgare L. (Barley, hulled six-row lemma base/grain)	-	-	-	-
Hordeum vulgare L. (Barley, six-row grain/lemma base)	-	-	-	-
Sorghum bicolor (L.) Moench (Sorghum grain)	-	-	-	-
cf. Sorghum bicolor (L.) Moench (cf. Sorghum grain)	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown (Pearl millet grain)	-	-	-	-
cf. *Pennisetum glaucum* (Linn.) R. Brown (Pearl millet grain	-	-	-	-
Various cereals (Indeterminate grain)	-	-	-	14
Cereal Chaff				
Triticum aestivum L. (Bread wheat type, rachis)	1	2	-	-
Triticum aestivum L. (Bread wheat type, basal rachis)	1	-	-	-
Triticum aestivum L. (Bread wheat type, near terminal rachis)	-	-	-	-
Triticum cf. aestivum L. (cf. Bread wheat type, rachis)	-	-	-	-
Triticum durum Desf. (Hard wheat rachis)	-	-	-	-
Triticum cf *durum* Desf. (cf. Hard wheat rachis)	-	-	-	-
Triticum aestivum/durum (Bread/Hard wheat rachis)	1	-	-	-
Triticum aestivum/durum (Bread/Hard wheat basal rachis)	-	-	-	-
Triticum sp. (Wheat, rachis internode)	-	-	-	-
Hordeum vulgare L. (Barley, dense-eared, stalked rachis)	-	-	-	-
Hordeum vulgare L. (Barley, dense-eared rachis)	-	-	-	-
Hordeum vulgare L. (Barley, six row rachis)	-	70	-	-
Hordeum vulgare L. (Barley, six-row basal rachis)	-	2	-	2
Hordeum vulgare L. (Barley, rachis)	1	165	-	1
cf. Hordeum vulgare L.(cf Barley rachis)	-	2	-	-
Sorghum bicolor var *durra* (Durra sorghum, spikelet)	-	-	-	-
Sorghum bicolor (L.) Moench (Sorghum (cultiv) glume base)	-	-	-	-

	04PF/107	05F/366	05F/389	05RF/401
Sorghum bicolor (L.) Moench (Sorghum glume frags)	-	-	-	-
cf. Sorghum bicolor (L.) Moench (Sorghum immature spikelet)	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown (Pearl millet ear segment)	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown (Pearl millet involucre)	-	-	-	-
Pennisetum sp. (involucre)	1	-	-	-
cf. *Pennisetum* sp. (involucre rachis and rachilla)	-	-	-	-
Cerealia indet (indeterminate rachis internode)	1	35	5	4
Cerealia indet (indeterminate basal rachis)	-	-	-	1
Cerealia indet (culm nodes, large)	4	1	-	-
Cerealia indet (Culm nodes small)	-	-	-	-
Chaff fragments not used in numerical analysis				
Triticum aestivum L. (Bread wheat type glume tip)	-	-	2	-
Triticum aestivum/durum (Bread/Hard wheat glume frags)	-	-	-	-
Triticum dicoccum/monococcum (Bread/Hard wheat glume base)	-	2	-	-
Triticum sp. (Wheat rachilla)	-	-	-	-
Hordeum vulgare L. (Barley lemma frags)	-	-	-	-
Triticum/Hordeum sp. (Wheat/Barley awn frags)	-	+++	71	-
Cerealia indet (straw lengths)	-	-	-	-
Cerealia indet (detached embryo)	-	-	-	-
Cerealia indet (bran 'beards')	-	-	-	-
Cerealia indet (bran frags)	-	-	-	-
Cerealia indet (light chaff general)	-	-	-	-
Pulses				
cf. *Vicia* sp. (hila)	-	-	-	-
cf. *Pisum* sp. (,hila)	-	-	-	-
Leguminoseae (hila)	-	-	-	-
Leguminoseae (seed)	1	-	-	-
Leguminoseae (testa frags)	-	-	-	-
Leguminoseae (pod frag)	-	-	-	-

	04PF/107	05F/366	05F/389	05RF/401
Fruit/Spices etc				
Ficus carica L. (Fig)	-	-	-	-
Vitis vinifera L. (Grape seed)	-	-	-	-
cf. *Vitis vinifera* L. (Grape seed)	-	-	-	-
Phoenix dactylifera L. (Date stone)	20	5	-	-
Phoenix dactylifera L. (Date perianth)	2	-	-	-
Phoenix dactylifera L. (Date, male flower)	-	-	-	-
Phoenix dactylifera L. (Date rachilla)	++	-	-	-
Phoenix dactylifera L. (Date embryo)	1			
Citrullus lanatus (Thunb.) Mats. & Nakai (Water melon seed)	3	-	-	-
Cucurbita sp. (Pumpkin/Squash etc. seed coat)	-	-	-	-
Cucumis sp. (Melon/Cucumber seed)	-	-	-	-
cf Cucumis sp. (Melon/Cucumber seed)	-	-	-	-
Cucumis melo L. (Melon seed)	-	-	-	-
Cucurbitaceae (seed fragment)	-	-	-	-
Linum usitatissimum L. (Flax, capsule fragments)	2	-	-	-
Linum usitatissimum L. (Flax, capsule tips)	-	-	-	-
Linum usitatissimum L. (Flax seeds)	-	-	-	-
Capsicum sp. (Sweet pepper/Chili seed)	1	-	-	-
Nigella sativa L. (Black cumin)	-	-	-	-
Cuminum cyminum L. (cf. Cumin)	-	-	-	-
Weeds				
Amaranthaceae				
Amaranthus sp.	-	-	-	-
Apiaceae				
Apiaceae large	1	-	-	-
Asteraceae				
Calendula sp.	3	-	-	-
Asteraceae indet (small seeded)	-	-	-	-

	04PF/107	05F/366	05F/389	05RF/401
Boraginaceae				
Heliotropium cf. *europaeum* L.	-	-	-	-
Brassicaceae				
Coronopus sp.	1	-	-	-
cf. *Raphanus raphanistrum* L. capsule frag.	-	-	-	-
Brassicaceae indet (small seeded)	-	-	-	-
Caryophyllaceae				
Silene cf. gallica L.	8	-	-	-
Caryophyllaceae small seeded	-	-	-	-
Chenopodiaceae				
Chenopodiaceae small seeded	2	-	-	-
Chenopodium murale L.	-	-	-	-
Suaeda sp.		-		
Cyperaceae				
cf. Carex sp.	-	-	-	-
Cladium mariscus (L.) R. Br.	-	-	-	-
Euphorbiaceae				
Euphorbia peplus L.	-	-	-	-
Fabaceae				
Alhagi sp. pod	18	-	-	-
Alhagi type seed	51	-	-	-
Fabaceae indet	-	-	-	-
Fabaceae large	-	-	-	-
Fabaceae small	-	-	-	-
Fumariaceae				
Fumaria sp.	21	-	-	-
Liliaceae				
Asphodelus cf. *tenuifolius* Cav.	8	-	-	-
Malvaceae				
Malva sp.	-	1	-	-

	04PF/107	05F/366	05F/389	05RF/401
Poaceae				
cf. *Digitaria* sp. glumes	-	-	-	-
Cynodon sp. lemma/palea	-	-	-	-
Cynodon sp.	6	-	-	-
Cynodon B type	-	-	-	-
Lolium/Festuca type small seeded	-	-	-	-
Festuca pratensis gp (*F.* cf. *arundinaceae)*	-	-	-	-
Lolium temulentum L. type	-	-	-	-
Lolium/Festuca type large seeded	-	-	-	-
Lolium/Festuca type large seeded, lemma/palea	-	-	-	-
Phalaris sp. caryopsis and glume	-	17	-	4
Phalaris sp. glumes	-	-	-	-
Setaria/Brachiaria type	2	13	-	6
Setaria/Brachiaria type lemma/palea	-	-	2	++
Setaria/Brachiaria small type	-	-	-	-
Brachiaria type	-	2	-	-
Poaceae indeterminate, large seeded	-	-	-	-
Poaceae indeterminate, small seeded	-	-	-	-
Poaceae indeterminate, chaff frags.	-	++	-	-
Polygonaceae				
Emex spinosa	1	-	-	-
Portulaceae				
Portulaca oleracea L.	584	-	-	-
cf. Portulaca oleracea L.	-	-	-	-
Primulaceae				
Anagalis arvensis L. type	5	-	-	-
Rutaceae				
Haplophyllum sp. seed capsule segment	-	-	-	-
Scrophulariaceae				
Linaria sp.	-	-	-	-

	04PF/107	05F/366	05F/389	05RF/401
Wild Fruits/Trees				
Tamarix sp., leaflets	3	-	-	-
Tamarix sp. flower	-	-	-	-
cf. Mimosaceae thorn	-	-	-	-
Indeterminate/Unidentified seeds				
Jarma Type 5	-	2	-	-
Other' seed	-	-	-	-
indeterminate seed	3	1	-	-
Unidentified Non-Seed Items				
cf. Monocotyledon epidermis	-	-	-	-
Myriophullym/Zylophyllum sp. stem frags	-	-	-	-
Type P leaves, small	13	-	-	-
Type P leaves, large	-	-	-	-
Other varied leaves	-	-	-	-
Large thorns	-	-	-	-
Indet bud/flower	2	-	-	-
Indet testa fragment	-	-	-	-
Total	772	320	80	32

Appendix three: The Charred Remains from Jarma (phases 1 to 3) (desiccated remains given where they occur in low numbers)

		01S/022	03PF/106	03CF/046	03F/102	03PF/105	03RF/108	03RF/117
CHARRED REMAINS								
Cereal Grain								
Triticum aestivum/durum	Bread/Hard wheat grain	1	1	1	-	2	1	-
Triticum cf aestivum/durum	cf. Bread/Hard wheat grain	-	-	-	-	-	-	-
*Triticum cf. dicoccum (*Schubl.)	cf. Emmer wheat grain	-	-	-	-	-	-	-
Triticum sp.	Wheat grain	-	-	-	-	4	-	-
cf. Triticum sp.	cf Wheat grain	-	-	-	-	1	-	-
Hordeum vulgare L.	Barley, hulled asymmetrical grain	-	2	-	1	-	-	1
Hordeum vulgare L.	Barley, hulled straight grain	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, hulled grain	-	-	-	3	1	-	-
Hordeum vulgare L.	Barley grain	1	5	-	11	-	3	1
Hordeum vulgare L.	Barley, hulled tail grain	-	-	-	-	-	-	-
cf. Hordeum vulgare L.	Barley, hulled grain	-	-	-	-	2	-	-
Avena sp.	Oats	-	-	-	-	-	-	-
Sorghum bicolor (L.) Moench	Sorghum grain	-	-	-	-	2	-	-
cf. Sorghum bicolor (L.) Moench	Sorghum grain	-	-	-	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet	5	124	2	-	4	-	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet, small seeded	-	151	-	-	6	-	-
cf. *Pennisetum glaucum (Linn.) R. Brown*	cf. Pearl millet	3	10	1	-	2	-	-
cf. Pennisetum glaucum (Linn.) R. Brown	cf. Pearl millet, small seeded	5	56	1	-	3	-	-
Cerealia indet.	Indeterminate cereal grain	-	1	-	6	-	-	1
Cerealia indet	Small seeded embryo ends	-	2	-	-	-	-	-
Chaff								
Triticum aestivum L.	Bread type wheat, rachis	40	19	-	-	48	-	-
Triticum aestivum L.	Bread type wheat, basal rachis	-	-	-	-	-	-	-
Triticum aestivum L.	Bread type wheat, near terminal rachis	-	-	-	-	-	-	-
Triticum cf. *aestivum* L.	cf. Bread type wheat rachis	13	-	-	-	-	-	-
Triticum cf. *aestivum* L.	cf. Bread type wheat, basal rachis	-	-	-	-	-	2	-
Triticum durum Desf.	Hard wheat rachis	1	-	-	-	-	-	-

		01S/022	03PF/106	03CF/046	03F/102	03PF/105	03RF/108	03RF/117
Triticum cf. *durum* Desf.	cf. Hard wheat rachis	-	-	-	-	4	-	-
Triticum X type	X type free-threshing wheat rachis	-	-	-	-	-	-	-
Triticum aestivum/durum	Bread/Hard wheat rachis	47	127	-	-	167	3	1
Triticum sp.	Wheat rachis	-	7	-	-	-	-	-
Triticum sp.	Wheat, basal rachis	6	2	-	-	5	-	-
cf. Triticum sp.	cf. Wheat basal rachis	-	-	-	-	-	-	-
Triticum sp.	Wheat rachis internode	-	-	-	-	9	-	-
Triticum dicoccum (Schubl.)	Emmer wheat glume base, silica	-	-	-	-	-	-	-
Triticum dicoccum/monococcum	Emmer/Einkorn rachis spikelet fork	-	-	-	-	-	-	-
Triticum dicoccum/monococcum	Emmer/Einkorn glume base, silica	-	-	-	-	-	-	-
Triticum sp.	Wheat glume base	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, dense eared stalked rachis	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, six-row rachis	36	10	-	10	-	9	1
Hordeum vulgare L.	Barley, dense eared rachis	6	-	-	-	8	-	-
Hordeum vulgare L.	Barley rachis	22	33	-	14	14	21	6
Hordeum vulgare L.	Barley basal rachis	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, rachis internode	-	-	-	-	-	-	1
cf. *Hordeum vulgare* L.	cf. Barley rachis	-	-	-	-	-	-	-
Avena sp.	floret base	-	-	-	-	-	-	-
Sorghum bicolor (L.) Moench	Sorghum glume base	-	-	1	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet involucre	2	-	-	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet rachilla	1	-	-	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet spikelet	6	-	-	-	-	-	-
Cerealia indet	Rachis	40	53	-	2	31	18	-
Cerealia indet	Basal rachis	-	-	-	5	9	-	-
Cereal size	Culm nodes, large	12	50	1	-	8	3	-
Cereal size	Culm nodes, small	-	-	-	-	-	-	-
Cereal size	Basal culm (root) nodes	2	-	-	-	-	-	-

		01S/022	03PF/106	03CF/046	03F/102	03PF/105	03RF/108	03RF/117
Chaff fragments not used in numerical analysis								
Triticum aestivum/durum	Bread/Hard wheat glume frags	6	-	-	+	+	-	-
Triticum sp.	Wheat, rachilla	6	-	-	-	-	-	-
Triticum sp.	Wheat, light chaff fragments	-	-	-	-	-	-	-
Triticum type	Wheat, short glume tip, silica	-	-	-	-	-	-	-
Triticum type	Wheat, awn/long glume tip, silica	-	-	-	-	-	-	-
Hordeum/Triticum sp.	Wheat/Barley awn fragment	1	-	-	-	-	-	-
Hordeum vulgare L.	Barley lemma frags	-	-	-	+++	-	-	-
Sorghum bicolor (L.) Moench	Sorghum glume frags	-	-	-	-	-	-	-
Cerealia indet	Rachilla	-	2	-	-	-	-	-
Cerealia indet	Detached embryo	3	3	-	4	-	1	-
Cerealia indet	Light chaff general	-	-	-	-	-	-	-
Cereal size	Straw lengths	5	-	-	-	-	-	-
Pulses								
cf. *Pisum sativum* L.	cf. Pea, hila	-	-	-	-	-	-	-
cf. *Vicia faba* L.	cf. Fava/Fûl bean hila/seed	-	-	-	-	-	-	-
cf. *Vigna unguiculata*	cf. Cow Pea hila	-	-	-	-	-	-	-
cf. *Lens esculenta* Moench.	cf. Lentil	-	-	-	-	1	-	-
Leguminoseae	hila	-	3	-	-	-	-	-
Leguminoseae	seed	-	4	-	-	-	-	-
Anacardiaceae/Leguminosease	seed	-	-	-	-	-	-	-
Fruit/Vegetables								
Ficus carica L.	Fig seed	-	4	-	-	-	2	1
cf. Ficus carica L.	Fig seed	-	-	-	-	-	-	-
Vitis vinifera L.	Grape seed	-	2	-	2	-	-	1
Vitis vinifera L.	Grape, whole fruit/raisin	-	1	-	-	-	-	-
Vitis vinifera L.	Grape, immature seed	-	-	-	-	-	-	-
cf. *Vitis vinifera* L.	cf. Grape seed	-	-	-	-	-	-	-
Vitis vinifera L.	Grape stalk	-	-	-	-	-	-	-

		01S/022	03PF/106	03CF/046	03F/102	03PF/105	03RF/108	03RF/117
Phoenix dactylifera L.	Date stone	5	10	1	13	15	4	12
Phoenix dactylifera L.	Date perianth	8	4	-	3	14	1	-
Phoenix dactylifera L.	Date rachilla	2	-	-	-	-	-	-
Phoenix dactylifera L.	Date embryo	-	3	-	4	-	1	2
Olea europea L.	Olive stone	-	-	-	-	-	-	-
Olea/Zizyphus sp.	Olive/Christ's-thorn stone	-	-	-	1	-	1	-
Citrullus sp.	Watermelon/Bitter Apple seed	-	-	-	-	-	-	-
Cucumis sp.	Melon/Cucumber seed	-	-	-	-	-	-	-
Lagenaria sp.	Gourd, seed	-	-	-	-	1	-	-
Cucurbitaceae	Internal seed	-	-	-	-	-	1	-
Cucurbitaceae	Seed fragment	-	-	-	-	-	-	-
cf. Cucurbitaceae	Seed	-	2	-	-	-	-	-
Punica granatum L.	Pomegranate seed	-	-	-	-	-	-	-
cf. Punica granatum	Pomegranate seed	-	-	-	-	-	-	-
Prunus amygdalus Batsch.	Almond	-	-	-	-	-	-	-
Capsicum sp.	Pepper/Chili seed	2	-	-	-	1	-	-
cf. *Apium graveolens* L.	Wild celery	-	-	-	-	-	-	-
cf. *Foeniculum vulgare* L.	Fennel		1					
cf. *Anethum graveolens* L.	Dill	-	1	-	-	-	-	-
cf. *Coriandrum sativum* L.	Coriander	-	-	-	-	-	-	-
cf. *Papaver somniferum* L.	Opium poppy	-	-	-	-	-	-	-
Indet berry		-	1	-	1	-	-	-
Other fruit stone frags (Prunus type)		-	-	-	-	-	-	-
Indet fruit	Fruit core?	-	-	-	-	-	-	-
Oil/Fibre Plants								
Linum usitatissimum L.	Flax capsule tips	1	-	-	-	-	-	-
Linum usitatissimum L.	Flax seeds	-	-	-	-	2	-	-
Gossypium sp.	Cotton (total seeds - mni)	-	-	-	1	-	-	2
cf. *Gossypium* sp.	cf. cotton (total)	-	-	-	1	-	-	-
Gossypium sp.	Cotton funicular apex	-	-	-	-	-	-	-

		01S/022	03PF/106	03CF/046	03F/102	03PF/105	03RF/108	03RF/117
cf. *Gossypium* sp.	Cotton internal seed	-	-	-	-	-	-	-
cf. *Sesamum* sp.	cf. Sesame seed	-	-	-	-	-	-	-
Herbaceous Plants								
Aizoaceae								
Aizoon cf. *hispanicum* L.		-	-	-	-	-	-	-
Amaranthaceae								
Amaranthus cf. *augustifolius* L.		-	-	-	-	7	-	-
cf. *Amaranthus* sp.		-	-	-	-	2	-	-
Chenopodiaceae/*Amaranthus* sp.		-	6	-	-	31	-	-
Chenopodiaceae/Amaranthaceae/Caryophyllaceae		-	-	-	-	6	-	-
Apiaceae								
Apiaceae Jarma A		-	-	-	2	-	-	-
Apiaceae large seeded		1	1	-	1	-	-	-
Apiaceae small seeded		-	-	-	-	-	-	-
Apiaceae indeterminate		-	-	-	-	-	-	-
Asteraceae								
Calendula cf. *arvensis* L./*tripterocarpa Rupr.*		-	-	-	-	-	-	-
cf. Calendula sp.		-	-	-	-	-	-	-
cf. Compositae small		-	-	-	-	-	-	-
cf. Compositae large (>2mm)		-	-	-	-	-	-	-
Boraginaceae								
Heliotropium cf. *europaeum* L.		-	-	-	-	-	-	-
Boraginaceae A		-	-	-	-	1	2	-
Boraginaceae B		-	-	-	-	-	-	-
Boraginaceae C		-	-	-	-	-	-	-
Boraginaceae indet								
Brassicaceae								
Coronopus sp.		2	-	-	-	-	-	-
Cruciferae V, seed capsule		-	-	-	-	-	-	-
Cruciferae		-	-	-	-	-	-	-

	01S/022	03PF/106	03CF/046	03F/102	03PF/105	03RF/108	03RF/117
Caryophyllaceae							
Silene cf. *gallica* L.	-	-	-	-	-	-	-
cf. Silene sp.	-	-	-	-	1	-	-
Caryophyllaceae, small seeded	-	-	-	-	-	-	-
Chenopodiaceae							
Chenopodium murale L.	-	-	-	-	-	-	1
cf. *Chenopodium murale* L.	-	-	-	-	-	-	-
Chenopodium sp.	-	-	-	-	-	-	-
Cornulaca monacantha Del. Utricles	-	-	-	-	-	-	-
Chenopodiaceae A	-	-	-	-	-	-	-
Chenopodiaceae small	-	-	-	-	-	-	-
Suaeda sp.	-	-	-	-	-	-	-
Cyperaceae							
Cladium mariscus (L.) R. Br.	-	-	-	-	1	-	-
cf. Cladium mariscus (L.) R. Br.	-	-	-	-	1	-	-
Cyperaceae A, silica	-	-	-	-	-	-	-
Cyperaceae	-	-	-	-	-	-	-
Euphorbiaceae							
Euphorbia helioscopia L.	-	-	-	-	-	-	-
Euphorbia peplus L.	1	-	-	-	-	-	-
Euphorbia sp.	-	-	-	-	-	-	-
cf. *Euphorbia* sp.	-	-	-	-	-	-	-
Fabaceae							
Alhagi sp. seeds in pods	3	-	-	-	11	-	-
Alhagi sp. pods	5	-	1	-	8	-	-
Alhagi type	10	-	1	2	85	-	-
Fabaceae indet	-	5	-	-	69	1	-
Fabaceae large/intermediate seeded, other	-	1	-	-	1	-	-
Vicia/Lathyrus sp. small seeded	-	-	-	-	-	-	-
Vicia/Lathyrus sp. intermediate	-	-	-	-	-	-	-
cf. *Onobrychis* sp. seed pod	-	-	-	-	-	-	-

	01S/022	03PF/106	03CF/046	03F/102	03PF/105	03RF/108	03RF/117
cf. *Onobrychis* sp. seed pod	-	-	-	-	-	-	-
Fumariaceae							
Fumaria sp.	-	-	-	-	-	-	-
Liliaceae							
Asphodelus cf. *tenuifolius*	-	-	-	-	-	-	-
Malvaceae							
Malva sp.	-	-	-	-	-	-	-
Plantaginaceae							
Plantago sp.	-	-	-	-	-	-	-
Poaceae							
Bromus type	-	-	-	-	-	-	-
cf. Bromus type	-	-	-	-	-	-	-
Dactyloctenium aegyptium (L.) Beauc.	-	-	-	-	-	-	-
Digitaria B	-	-	-	-	-	-	-
cf. Digitaria type	-	1	-	-	-	-	-
*Eleusine cf. indica (*L.) Gartn.	-	4	-	-	-	-	-
Cynodon sp.	-	-	1	-	34	-	-
cf. *Cynodon* sp.	7	-	-	-	28	-	-
Cynodon B type	-	15	-	-	-	-	-
cf. *Cynodon* B type	-	-	-	-	-	-	-
Hordeum sp.	-	-	-	2	-	-	-
cf. Hordeum sp.	-	-	-	-	-	-	-
Lolium/Festuca type	-	5	-	-	-	-	-
cf. Lolium/Festuca type	1	-	1	-	-	-	-
Festuca pratensis gp	-	-	-	-	4	-	-
Paniceae indet	-	7	-	-	3	-	-
Paniceae indet, lemma/palea only	-	-	-	-	-	-	-
Paniceae indet very small	-	-	-	-	-	-	-
Panicum cf. *turgidum* Forsk.	-	-	-	-	-	-	-
Panicum cf. *repens* L.	-	2	-	-	-	23	-
cf. Panicum repens L.	-	-	-	-	-	4	-

	01S/022	03PF/106	03CF/046	03F/102	03PF/105	03RF/108	03RF/117
cf. Panicum sp.	-	-	-	-	-	-	-
Phalaris sp.	-	-	-	-	-	-	-
cf. Phalaris sp.	-	-	-	1	-	-	-
Polypogon sp.	-	-	-	-	-	-	-
Setaria/Brachiaria/Echinochloa type	-	8	-	-	-	1	-
Setaria verticillata type	-	2	-	-	-	-	-
Setaria verticillata/Brachiaria ramosa type	-	3	-	-	-	1	-
Setaria small	-	-	-	-	-	-	-
Brachiaria ramosa/deflexa type	-	3	-	-	-	-	-
Brachiaria ramosa/deflexa type, palea/lemma intact	-	-	-	-	-	-	-
cf. *Brachiaria ramosa/deflexa type*	-	-	-	-	-	-	-
Paspalum cf. paspaloides	-	-	-	-	-	-	-
Poaceae 4	-	-	-	-	-	-	-
Poaceae N	1	-	-	-	-	-	-
Poaceae O	-	-	-	-	-	-	-
Poaceae R	-	-	-	-	-	-	-
Poaceae Z	-	1	-	-	-	-	-
Poaceae indeterminate large seeded	2	3	-	5	4	-	-
Poaceae, indeterminate small seeded	3	18	-	-	10	12	-
Poaceae (detached embryo)	-	2	-	1	2	2	-
Polygonaceae							
Polygonaceae indet	-	-	-	-	-	-	-
Portulaca							
Portulaca oleracea	9	-	-	-	59	-	-
cf. *Portulaca oleracea*	2	-	-	-	7	-	-
Primulaceae							
cf. *Anagallis arvensis*	-	-	-	-	2	-	-
Rubiaceae							
Galium sp.	-	-	-	-	-	-	-
Rutaceae							
Haplophyllum sp.	-	-	-	-	-	-	-

	01S/022	03PF/106	03CF/046	03F/102	03PF/105	03RF/108	03RF/117
Haplophyllum sp. (seed capsule	-	-	-	-	-	-	-
Resedaceae							
Reseda cf. *lutea* L.	-	-	-	-	-	-	-
Reseda villosa/alba	-	-	-	-	-	-	-
Scrophulariaceae							
Linaria sp.	-	-	-	-	-	-	-
Solonaceae							
Solanum nigrum	-	9	-	-	7	-	-
cf. Solanum nigrum	-	-	1	-	-	-	-
Solonaceae indet	-	-	-	-	-	-	-
Trees/Wild fruits							
Zizyphus spina-christi (L.) Desf. fruit	-	-	-	-	-	-	-
Zizyphus sp.,	-	-	-	-	-	-	-
cf. *Zizyphus* sp.	-	-	-	-	-	-	-
Prosopis sp.	-	-	-	-	-	-	-
cf. *Prosopis* sp.	-	1	-	-	-	-	-
cf. *Acacia* sp.	-	1	-	-	-	-	-
Acacia/Prosopis type	-	1	-	-	-	-	-
Phoenix dactylifera L. frond fragments	-	-	-	-	+++	-	-
Tamarix sp. leaflets	34	-	24	-	-	-	-
cf. Mimosaceae thorns	-	-	3	-	-	-	-
Indeterminate/Unidentified Seeds							
Jarma type W	-	-	-	-	-	-	-
Jarma TypeT	-	-	-	-	-	1	-
Jarma Type F	-	-	-	-	1	-	-
cf. Jarma Type F	-	1	-	-	-	-	-
Jarma Type 5	-	-	-	-	-	-	-
Indet small <1.5 mm	14	23	-	-	18	6	-
indet >1.5mm	4	1	1	9	9	-	1

		01S/022	03PF/106	03CF/046	03F/102	03PF/105	03RF/108	03RF/117
indet unclassified		-	3	-	9	1-	-	-
Other Query Seeds		-	-	-	-	-	-	-
Other (non-seed) plant items								
Type P leaves		2	-	5	-	10	10	-
Indeterminate leaves		-	-	-	-	11	12	-
Indeterminate leaf bud		-	-	-	-	-	-	-
Indeterminate fruit skin fragment		-	-	-	-	-	-	-
Indeterminate bud/flower		4	-	-	1	1	-	-
Indeterminate large thorns		-	-	-	-	-	-	-
Charcoal		-	++	-	-	-	-	-
MINERALISED PLANT REMAINS								
Ficus carica L.		-	-	-	-	-	-	-
Apiaceae		-	-	-	-	-	-	-
Apiaceae		-	-	-	-	-	-	-
Indet		-	-	-	-	-	-	-
DESICCATED PLANT REMAINS (where fewer than 30 items per sample)								
Cereal Grain								
Hordeum vulgare L.	Barley, hulled grain	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley grain	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, six-row grain/lemma base	-	-	-	5	-	-	-
Triticum aestivum L.	Bread wheat type, rachis	-	-	-	2	3	-	-
Triticum durum Desf.	Hard wheat rachis	-	-	-	-	3	-	-
Triticum aestivum/durum	Bread/Hard wheat rachis	-	-	-	-	-	-	-
Triticum aestivum/durum	Bread/Hard wheat basal rachis	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, six row rachis	-	-	-	1	-	-	-
Hordeum vulgare L.	Barley, rachis	-	-	-	5	-	-	-
cf. Hordeum vulgare L.	cf. Barley rachis, desiccated	-	-	-	-	-	-	-

		01S/022	03PF/106	03CF/046	03F/102	03PF/105	03RF/108	03RF/117
Pennisetum glaucum(Linn.) R. Brown	Pearl millet involucre	-	-	-	-	-	-	-
Cerealia indet	indeterminate rachis internode	-	-	-	4	-	-	-
Triticum aestivum/durum	Bread/Hard wheat glume frags	-	-	-	-	-	-	-
Triticum dicoccum/monococcum	Bread/Hard wheat glume base	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley lemma frags	-	-	-	-	-	-	-
Hordeum/Triticum sp.	awn frags, desist	-	-	-	-	-	-	-
Cerealia indet	straw lengths	-	-	-	-	-	-	++
Cerealia indet	light chaff general	-	-	-	-	-	-	-
Vitis vinifera L.	Grape seed	-	-	-	-	-	-	-
Brassicaceae indet (small seeded)		-	-	-	-	-	-	-
cf. Carex sp.		-	-	-	-	-	-	-
cf. *Digitaria* sp. glumes		-	-	-	-	-	-	-
Phalaris sp. caryopsis and glume		-	-	-	-	-	-	-
Phalaris sp. glumes		-	-	-	-	-	-	-
Setaria/Brachiaria type		-	-	-	-	-	-	-
Setaria/Brachiaria type lemma/palea		-	-	-	-	-	-	-
Setaria/Brachiaria small type		-	-	-	1	-	-	-
Poaceae indeterminate, small seeded		-	-	-	-	1	-	-
Linaria sp.		-	-	-	-	-	-	-
Tamarix sp., leaflets		-	-	-	-	-	-	-
Jarma Type 5		-	-	-	-	-	-	-
Other' seed		-	-	-	-	-	-	-
indeterminate seed		-	-	-	-	-	4	-
Type P leaves, small		-	-	-	-	-	12	-
Indet bud/flower		-	-	-	-	1	-	-
Non-Plant Items								
Sheep/goat droppings charred		-	-	-	++	+++	-	-
Sheep/goat droppings desiccated		-	-	+++	++	-	-	-
Dung lumps		-	-	-	-	-	-	-
Mouse droppings		-	-	-	-	-	-	-

	01S/022	03PF/106	03CF/046	03F/102	03PF/105	03RF/108	03RF/117
Fly pupae, desiccated	-	-	-	-	-	-	-
Fly pupae mineralised	-	-	-	-	-	-	-
Fly pupae charred	-	6	-	-	-	-	-
Large insect pupae? desiccated	-	-	-	-	2	-	-
Other insect fragment, charred	+	2	-	-	1	-	-
Bone fragments	-	-	-	-	-	-	-
Tooth	-	-	-	-	-	-	-
Fish bone	-	-	-	-	-	-	-
Printed/painted cloth frog., not-charred	1	-	-	-	-	-	-
Indet charred cloth	-	-	-	-	-	-	-

Appendix 3: The Charred Remains from Jarma (phases 3 to 4)

		03S/364	03F/367	04S/104	04CF/129	04F/383	04RF/121	04I/128	04I/511
CHARRED REMAINS									
Cereal Grain									
Triticum aestivum/durum	Bread/Hard wheat grain	-	-	-	-	1	-	2	-
Triticum cf aestivum/durum	cf. Bread/Hard wheat grain	-	-	-	-	-	-	-	-
*Triticum cf. dicoccum (*Schubl.)	cf. Emmer wheat grain	-	-	-	-	-	-	-	-
Triticum sp.	Wheat grain	1	-	-	2	-	-	5	-
cf. Triticum sp.	cf Wheat grain	-	-	-	-	1	-	-	-
Hordeum vulgare L.	Barley, hulled asymmetrical grain	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, hulled straight grain	-	-	-	-	3	1	-	-
Hordeum vulgare L.	Barley, hulled grain	1	4	2	10	3	3	24	-
Hordeum vulgare L.	Barley grain	4	5	-	2	2	3	-	1
Hordeum vulgare L.	Barley, hulled tail grain	-	-	-	-	-	-	-	-
cf. Hordeum vulgare L.	Barley, hulled grain	-	-	-	-	-	-	-	-
Avena sp.	Oats	-	-	-	-	-	-	-	1
Sorghum bicolor (L.) Moench	Sorghum grain	-	-	-	-	-	-	4	-
cf. Sorghum bicolor (L.) Moench	Sorghum grain	-	-	-	-	-	-	3	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet	-	-	1	18	-	-	1	2
Pennisetum glaucum (Linn.) R. Brown	Pearl millet, small seeded	-	-	-	-	-	-	7	-
cf. *Pennisetum glaucum (Linn.) R. Brown*	cf. Pearl millet	-	-	9	4	1	-	2	-
cf. Pennisetum glaucum (Linn.) R. Brown	cf. Pearl millet, small seeded	-	-	-	2	-	-	5	-
Cerealia indet.	Indeterminate cereal grain	7	11	2	1	5	7	4	2
Cerealia indet	Small seeded embryo ends	-	-	-	-	-	-	-	-
Chaff									
Triticum aestivum L.	Bread type wheat, rachis	-	-	-	1	3	1	-	2
Triticum aestivum L.	Bread type wheat, basal rachis	-	-	-	-	-	-	-	-
Triticum aestivum L.	Bread type wheat, near terminal rachis	-	-	-	-	-	-	-	-
Triticum cf. *aestivum* L.	cf. Bread type wheat rachis	-	-	1	-	-	-	-	-
Triticum cf. *aestivum* L.	cf. Bread type wheat, basal rachis	-	-	-	-	-	-	-	-
Triticum durum Desf.	Hard wheat rachis	-	-	-	-	-	-	-	-

		03S/364	03F/367	04S/104	04CF/129	04F/383	04RF/121	04I/128	04I/511
Triticum cf. *durum* Desf.	cf. Hard wheat rachis	-	-	-	-	-	-	-	-
Triticum X type	X type free-threshing wheat rachis	-	-	-	-	-	-	32	-
Triticum aestivum/durum	Bread/Hard wheat rachis	1	-	8	2	2	1	55	1
Triticum sp.	Wheat rachis	-	-	-	-	-	-	-	-
Triticum sp.	Wheat, basal rachis	-	-	-	5	-	-	5	-
cf. Triticum sp.	cf. Wheat basal rachis	-	-	-	-	-	-	-	-
Triticum sp.	Wheat rachis internode	-	-	-	-	-	-	-	-
Triticum dicoccum (Schubl.)	Emmer wheat glume base, silica	-	-	-	-	-	-	-	-
Triticum dicoccum/monococcum	Emmer/Einkorn rachis spikelet fork	-	-	-	-	-	-	-	-
Triticum dicoccum/monococcum	Emmer/Einkorn glume base, silica	-	-	-	-	-	-	-	-
Triticum sp.	Wheat glume base	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, dense eared stalked rachis	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, six-row rachis	-	-	6	1	1	-	-	3
Hordeum vulgare L.	Barley, dense eared rachis	-	-	-	-	-	-	74	-
Hordeum vulgare L.	Barley rachis	-	2	-	11	6	6	217	4
Hordeum vulgare L.	Barley basal rachis	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, rachis internode	-	-	4	-	-	-	-	-
cf. *Hordeum vulgare* L.	cf. Barley rachis	-	-	-	-	-	-	-	-
Avena sp.	floret base	-	-	-	-	-	-	-	-
Sorghum bicolor (L.) Moench	Sorghum glume base	-	-	-	-	-	-	1	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet involucre	-	-	-	-	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet rachilla	-	-	-	-	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet spikelet	-	-	-	-	-	-	-	-
Cerealia indet	Rachis	-	-	2	-	2	4	304	-
Cerealia indet	Basal rachis	-	-	1	-	-	-	13	-
Cereal size	Culm nodes, large	-	-	1	3	2	-	186	-
Cereal size	Culm nodes, small	-	-	-	-	-	-	-	-
Cereal size	Basal culm (root) nodes	-	-	-	-	-	-	41	-

		03S/364	03F/367	04S/104	04CF/129	04F/383	04RF/121	04I/128	04I/511
Chaff fragments not used in numerical analysis									
Triticum aestivum/durum	Bread/Hard wheat glume frags	-	-	-	-	2	-	-	-
Triticum sp.	Wheat, rachilla	-	-	-	-	-	-	-	-
Triticum sp.	Wheat, light chaff fragments	-	-	-	-	+	-	-	-
Triticum type	Wheat, short glume tip, silica	-	-	-	-	-	-	-	16
Triticum type	Wheat, awn/long glume tip, silica	-	-	-	-	-	-	-	5
Hordeum/Triticum sp.	Wheat/Barley awn fragment	-	-	-	++	-	-	-	8
Hordeum vulgare L.	Barley lemma frags	-	-	-	-	+	-	-	-
Sorghum bicolor (L.) Moench	Sorghum glume frags	-	-	-	-	-	-	-	-
Cerealia indet	Rachilla	-	-	-	-	-	-	-	-
Cerealia indet	Detached embryo	-	1	4	1	7	-	-	-
Cerealia indet	Light chaff general	++	-	-	-	-	-	-	-
Cereal size	Straw lengths	-	-	-	-	-	-	-	-
Pulses									
cf. *Pisum sativum* L.	cf. Pea, hila	-	-	-	-	-	-	-	-
cf. *Vicia faba* L.	cf. Fava/Fûl bean hila/seed	-	-	-	-	-	-	-	-
cf. *Vigna unguiculata*	cf. Cow Pea hila	-	-	-	-	-	-	-	-
cf. *Lens esculenta* Moench.	cf. Lentil	-	-	-	-	-	1	-	-
Leguminoseae	hila	-	-	-	-	-	-	-	-
Leguminoseae	seed	-	-	-	-	-	-	-	-
Anacardiaceae/Leguminosease	seed	-	-	-	-	-	-	-	-
Fruit/Vegetables									
Ficus carica L.	Fig seed	2	-	-	45	13	10	331	-
cf. Ficus carica L.	Fig seed	-	-	-	-	-	-	-	-
Vitis vinifera L.	Grape seed	1	-	-	10	2	11	42	-
Vitis vinifera L.	Grape, whole fruit/raisin	-	-	-	-	-	-	-	-
Vitis vinifera L.	Grape, immature seed	-	-	-	-	-	-	-	-
cf. *Vitis vinifera* L.	cf. Grape seed	-	-	-	-	1	-	-	-
Vitis vinifera L.	Grape stalk	-	-	-	-	-	-	1	-

		03S/364	03F/367	04S/104	04CF/129	04F/383	04RF/121	04I/128	04I/511
Phoenix dactylifera L.	Date stone	6	8	1	13	10	2	44	3
Phoenix dactylifera L.	Date perianth	9	1	1	4	2	-	12	-
Phoenix dactylifera L.	Date rachilla	2	-	-	1	-	-	4	-
Phoenix dactylifera L.	Date embryo	4	2	-	6	8	-	-	-
Olea europea L.	Olive stone	-	-	-	-	-	-	-	-
Olea/Zizyphus sp.	Olive/Christ's-thorn stone	1	-	-	-	-	1	-	1
Citrullus sp.	Watermelon/Bitter Apple seed	-	-	-	-	-	-	-	-
Cucumis sp.	Melon/Cucumber seed	-	-	-	-	-	-	-	-
Lagenaria sp.	Gourd, seed	-	-	-	-	-	-	-	-
Cucurbitaceae	Internal seed	-	-	-	-	-	-	1	-
Cucurbitaceae	Seed fragment	-	-	-	-	-	-	-	-
cf. Cucurbitaceae	Seed	-	-	-	1	-	-	-	-
Punica granatum L.	Pomegranate seed	-	-	-	-	-	-	-	-
cf. Punica granatum	Pomegranate seed	-	-	-	-	-	-	-	-
Prunus amygdalus Batsch.	Almond	-	-	-	-	-	-	-	-
Capsicum sp.	Pepper/Chili seed	-	-	-	-	-	-	-	-
cf. *Apium graveolens* L.	Wild celery	-	-	-	1	-	-	-	-
cf. *Foeniculum vulgare* L.	Fennel								
cf. *Anethum graveolens* L.	Dill	-	-	-	-	-	-	-	-
cf. *Coriandrum sativum* L.	Coriander	-	-	-	-	-	-	-	-
cf. *Papaver somniferum* L.	Opium poppy	-	-	-	-	-	-	-	-
Indet berry		-	-	-	-	-	-	-	-
Other fruit stone frags (Prunus type)		1	-	-	-	-	-	-	-
Indet fruit	Fruit core?	-	-	-	-	-	-	-	-
Oil/Fibre Plants									
Linum usitatissimum L.	Flax capsule tips	-	-	-	-	-	-	-	-
Linum usitatissimum L.	Flax seeds	-	-	-	1	-	-	1	-
Gossypium sp.	Cotton (total seeds - mni)	-	1	-	-	1	-	9	-
cf. *Gossypium* sp.	cf. cotton (total)	-	-	-	-	4	-	-	1
Gossypium sp.	Cotton funicular apex	-	-	-	-	-	-	1	-

		03S/364	03F/367	04S/104	04CF/129	04F/383	04RF/121	04I/128	04I/511
cf. *Gossypium* sp.	Cotton internal seed	1	-	-	-	-	-	-	-
cf. *Sesamum* sp.	cf. Sesame seed	-	-	-	-	-	-	-	-
Herbaceous Plants									
Aizoaceae									
Aizoon cf. *hispanicum* L.		-	-	-	2	1	-	-	-
Amaranthaceae									
Amaranthus cf. *augustifolius* L.		-	-	-	-	-	-	-	-
cf. *Amaranthus* sp.		-	-	-	-	-	-	1	-
Chenopodiaceae/*Amaranthus* sp.		-	-	-	-	-	-	-	-
Chenopodiaceae/Amaranthaceae/Caryophyllaceae			-	-	-	-	-	-	-
Apiaceae									
Apiaceae Jarma A		-	-	-	-	-	1	55	-
Apiaceae large seeded		-	-	-	-	-	1	-	-
Apiaceae small seeded		-	-	-	-	-	-	-	-
Apiaceae indeterminate		-	-	-	-	-	1	-	-
Asteraceae									
Calendula cf. *arvensis* L./*tripterocarpa Rupr.*			-	-	-	-	-	1	-
cf. Calendula sp.		-	-	-	-	-	-	-	-
cf. Compositae small		-	-	-	-	-	-	-	-
cf. Compositae large (>2mm)		-	-	-	-	-	-	-	-
Boraginaceae									
Heliotropium cf. *europaeum* L.		-	-	-	-	-	-	-	-
Boraginaceae A		3	-	-	-	-	1	1	-
Boraginaceae B		-	-	-	-	-	-	-	-
Boraginaceae C		-	-	-	-	-	-	-	-
Boraginaceae indet									
Brassicaceae									
Coronopus sp.		-	-	-	-	-	-	-	-
Cruciferae V, seed capsule		-	-	-	-	-	-	-	-
Cruciferae		-	-	-	-	-	-	-	-

	03S/364	03F/367	04S/104	04CF/129	04F/383	04RF/121	04I/128	04I/511
Caryophyllaceae								
Silene cf. *gallica* L.	-	-	-	-	-	-	-	-
cf. Silene sp.	-	-	-	-	-	-	-	-
Caryophyllaceae, small seeded	-	-	-	-	-	-	8	-
Chenopodiaceae								
Chenopodium murale L.	-	-	-	-	-	-	2	-
cf. *Chenopodium murale* L.	-	-	-	-	-	-	-	-
Chenopodium sp.	-	-	-	-	-	-	1	-
Cornulaca monacantha Del. Utricles	-	-	-	1	-	-	-	-
Chenopodiaceae A	-	-	-	-	-	-	-	-
Chenopodiaceae small	-	-	1	1	-	-	11	-
Suaeda sp.	3	-	-	-	-	-	-	-
Cyperaceae								
Cladium mariscus (L.) R. Br.	-	-	-	-	-	-	-	-
cf. Cladium mariscus (L.) R. Br.	-	-	-	-	-	-	-	-
Cyperaceae A, silica	-	-	-	-	-	-	-	-
Cyperaceae	-	-	-	-	-	-	-	-
Euphorbiaceae								
Euphorbia helioscopia L.	-	-	-	-	-	-	1	-
Euphorbia peplus L.	-	-	-	-	-	-	1	-
Euphorbia sp.	-	-	-	-	-	-	1	-
cf. *Euphorbia* sp.	-	-	-	-	-	-	-	-
Fabaceae								
Alhagi sp. seeds in pods	-	-	-	-	-	-	-	-
Alhagi sp. pods	-	-	-	-	-	-	-	-
Alhagi type	-	-	1	4	-	-	8	-
Fabaceae indet	-	-	-	6	-	1	11	-
Fabaceae large/intermediate seeded, other		-	-	-	-	-	-	-
Vicia/Lathyrus sp. small seeded	-	-	-	-	-	-	2	-
Vicia/Lathyrus sp. intermediate	-	-	-	3	-	-	-	-
cf. *Onobrychis* sp. seed pod	-	-	-	-	-	-	-	-

	03S/364	03F/367	04S/104	04CF/129	04F/383	04RF/121	04I/128	04I/511
cf. *Onobrychis* sp. seed pod	-	-	-	-	-	-	-	-
Fumariaceae								
Fumaria sp.	-	-	-	-	-	-	-	-
Liliaceae								
Asphodelus cf. *tenuifolius*	-	-	-	1	-	-	11	-
Malvaceae								
Malva sp.	-	-	-	-	-	-	-	-
Plantaginaceae								
Plantago sp.	-	-	-	-	1	-	5	-
Poaceae								
Bromus type	-	-	-	-	-	-	-	-
cf. Bromus type	-	-	-	-	-	-	-	-
Dactyloctenium aegyptium (L.) Beauc.	-	-	-	-	-	-	1	-
Digitaria B	-	-	-	-	-	-	-	-
cf. Digitaria type	-	-	-	-	-	-	-	-
*Eleusine cf. indica (*L.) Gartn.	-	-	-	-	-	-	-	-
Cynodon sp.	-	-	-	-	-	-	-	-
cf. *Cynodon* sp.	-	-	-	-	-	-	-	-
Cynodon B type	-	-	1	-	-	-	-	-
cf. *Cynodon* B type	-	-	-	-	-	-	-	-
Hordeum sp.	-	-	-	1	1	-	16	-
cf. Hordeum sp.	-	-	-	-	-	-	-	-
Lolium/Festuca type	-	-	-	-	-	-	-	-
cf. Lolium/Festuca type	-	-	-	-	-	-	-	-
Festuca pratensis gp	-	-	-	-	-	-	-	-
Paniceae indet	-	-	-	1	-	-	1	-
Paniceae indet, lemma/palea only	-	-	-	-	-	-	-	-
Paniceae indet very small	-	-	1	-	-	-	-	-
Panicum cf. *turgidum* Forsk.	-	-	-	-	-	-	-	-
Panicum cf. *repens* L.	-	-	-	5	-	2	9	-
cf. Panicum repens L.	-	-	-	-	-	-	-	-

	03S/364	03F/367	04S/104	04CF/129	04F/383	04RF/121	04I/128	04I/511
cf. Panicum sp.	-	-	-	-	-	-	-	-
Phalaris sp.	-	-	-	-	1	-	3	-
cf. Phalaris sp.	-	-	-	-	-	-	-	-
Polypogon sp.	-	-	-	-	-	-	-	-
Setaria/Brachiaria/Echinochloa type	-	-	-	1	-	2	3	-
Setaria verticillata type	-	-	-	-	-	-	-	-
Setaria verticillata/Brachiaria ramosa type	-	-	-	-	-	1	1	-
Setaria small	-	-	-	-	-	-	-	-
Brachiaria ramosa/deflexa type		-	-	1	-	1	17	-
Brachiaria ramosa/deflexa type, palea/lemma intact		-	-	-	-	-	6	-
cf. *Brachiaria ramosa/deflexa type*	-	-	-	-	-	-	-	-
Paspalum cf. paspaloides	-	-	-	-	-	-	1	-
Poaceae 4	-	-	-	-	-	-	-	-
Poaceae N	-	-	-	-	-	-	-	-
Poaceae O	-	-	-	-	-	-	4	-
Poaceae R	-	-	-	2	-	-	-	-
Poaceae Z	-	-	-	-	-	-	-	-
Poaceae indeterminate large seeded	-	-	-	1	1	-	-	-
Poaceae, indeterminate small seeded	-	2	6	2	1	-	15	-
Poaceae (detached embryo)	-	-	-	-	-	-	-	-
Polygonaceae								
Polygonaceae indet	-	-	-	-	-	-	-	-
Portulaca								
Portulaca oleracea	-	-	1	-	-	-	-	-
cf. *Portulaca oleracea*	-	-	-	-	-	-	4	-
Primulaceae								
cf. *Anagallis arvensis*	-	-	-	3	1	-	4	-
Rubiaceae								
Galium sp.	-	-	-	-	-	-	-	-
Rutaceae								
Haplophyllum sp.	-	-	-	-	-	-	6	-

	03S/364	03F/367	04S/104	04CF/129	04F/383	04RF/121	04I/128	04I/511
Haplophyllum sp. (seed capsule	-	-	-	-	-	-	1	-
Resedaceae								
Reseda cf. *lutea* L.	-	-	-	-	-	-	-	-
Reseda villosa/alba	-	-	-	-	-	-	-	-
Scrophulariaceae								
Linaria sp.	-	-	-	-	-	-	-	-
Solonaceae								
Solanum nigrum	-	-	-	6	-	2	43	-
cf. Solanum nigrum	-	-	-	-	-	-	-	-
Solonaceae indet	-	-	-	-	1	-	-	-
Trees/Wild fruits								
Zizyphus spina-christi (L.) Desf. fruit	-	-	-	-	-	-	-	-
Zizyphus sp.,	-	-	-	-	-	-	-	-
cf. *Zizyphus* sp.	-	-	-	-	-	-	-	-
Prosopis sp.	-	-	-	-	-	-	-	-
cf. *Prosopis* sp.	-	-	-	-	-	-	-	-
cf. *Acacia* sp.	-	-	-	-	-	-	-	-
Acacia/Prosopis type	-	-	-	-	-	-	-	-
Phoenix dactylifera L. frond fragments	-	-	-	-	-	-	-	-
Tamarix sp. leaflets	-	-	-	-	-	-	17	-
cf. Mimosaceae thorns	-	-	-	1	-	-	-	-
Indeterminate/Unidentified Seeds								
Jarma type W	-	-	-	-	-	-	-	-
Jarma TypeT	-	-	-	-	-	-	-	-
Jarma Type F	-	-	-	-	-	-	-	-
cf. Jarma Type F	-	-	-	-	-	-	-	-
Jarma Type 5	-	1	-	-	-	-	-	-
Indet small <1.5 mm	-	-	6	17	4	-	14	-
indet >1.5mm	3	-	4	5	3	-	-	-

		03S/364	03F/367	04S/104	04CF/129	04F/383	04RF/121	04I/128	04I/511
indet unclassified		4	5	1	11	-	1	-	-
Other Query Seeds		-	-	-	-	1	-	-	-
Other (non-seed) plant items									
Type P leaves		-	-	-	-	-	-	3	-
Indeterminate leaves		-	-	-	-	-	-	3	-
Indeterminate leaf bud		-	-	-	-	-	-	-	-
Indeterminate fruit skin fragment		-	-	-	-	-	-	-	-
Indeterminate bud/flower		-	1	-	-	-	-	1	-
Indeterminate large thorns		-	-	-	-	-	-	-	-
Charcoal		-	-	-	-	-	-	-	-
MINERALISED PLANT REMAINS									
Ficus carica L.		-	-	-	-	-	-	-	-
Apiaceae		-	-	-	-	-	-	-	-
Apiaceae		-	-	-	-	-	-	-	-
Indet		-	-	-	-	-	-	-	-
DESICCATED PLANT REMAINS (where fewer than 30 items per sample)									
Cereal Grain									
Hordeum vulgare L.	Barley, hulled grain	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley grain	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, six-row grain/lemma base	-	-	-	-	1	-	-	-
Triticum aestivum L.	Bread wheat type, rachis	-	-	-	1	-	-	-	-
Triticum durum Desf.	Hard wheat rachis	-	-	-	-	-	-	-	-
Triticum aestivum/durum	Bread/Hard wheat rachis	-	-	-	-	-	-	2	-
Triticum aestivum/durum	Bread/Hard wheat basal rachis	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, six row rachis	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, rachis	-	-	-	3	2	-	-	-
cf. Hordeum vulgare L.	cf. Barley rachis, desiccated	-	-	-	-	-	-	-	-

		03S/364	03F/367	04S/104	04CF/129	04F/383	04RF/121	04I/128	04I/511
Pennisetum glaucum(Linn.) R. Brown	Pearl millet involucre	-	-	-	-	-	-	-	-
Cerealia indet	indeterminate rachis internode	-	-	-	2	-	-	-	-
Triticum aestivum/durum	Bread/Hard wheat glume frags	-	-	-	-	-	-	-	-
Triticum dicoccum/monococcum	Bread/Hard wheat glume base	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley lemma frags	-	-	-	-	-	-	-	-
Hordeum/Triticum sp.	awn frags, desist	-	-	-	++	+	-	-	-
Cerealia indet	straw lengths	-	-	-	-	-	-	-	-
Cerealia indet	light chaff general	-	-	-	-	-	-	-	-
Vitis vinifera L.	Grape seed	-	-	-	-	-	-	-	-
Brassicaceae indet (small seeded)		-	-	-	-	-	1	-	-
cf. Carex sp.		-	-	-	-	-	-	-	-
cf. *Digitaria* sp. glumes		-	-	-	-	-	-	-	-
Phalaris sp. caryopsis and glume		-	-	-	-	-	-	-	-
Phalaris sp. glumes		-	-	-	-	-	-	-	-
Setaria/Brachiaria type		-	-	-	-	-	-	-	-
Setaria/Brachiaria type lemma/palea		-	-	-	-	-	-	-	-
Setaria/Brachiaria small type		-	-	-	-	-	-	-	-
Poaceae indeterminate, small seeded		-	-	-	-	-	-	-	-
Linaria sp.		-	-	-	-	-	-	-	-
Tamarix sp., leaflets		-	-	-	-	-	-	-	-
Jarma Type 5		-	-	-	-	-	-	-	-
Other' seed		-	-	-	-	-	-	-	-
indeterminate seed		-	-	-	-	-	-	-	-
Type P leaves, small		-	-	-	-	-	-	-	-
Indet bud/flower		-	-	-	-	-	-	-	-
Non-Plant Items									
Sheep/goat droppings charred		-	++	-	+++	-	-	-	-
Sheep/goat droppings desiccated		-	++	-	+++	-	-	-	-
Dung lumps		-	-	-	-	-	-	-	-
Mouse droppings		-	-	-	-	-	-	-	-

Fly pupae, desiccated	03S/364	03F/367	04S/104	04CF/129	04F/383	04RF/121	04I/128	04I/511
Fly pupae mineralised	-	-	-	-	-	-	-	-
Fly pupae charred	-	-	-	-	-	-	-	-
Large insect pupae? desiccated	-	-	-	-	-	-	-	-
Other insect fragment, charred	-	-	-	-	-	-	-	-
Bone fragments	-	-	-	-	-	-	-	-
Tooth	-	-	-	-	-	-	-	-
Fish bone	-	-	-	-	-	-	-	-
Printed/painted cloth frog., not-charred	-	-	-	-	-	2	-	-
Indet charred cloth	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-

Appendix 3 cont: The Charred Remains from Jarma (phase 5)

		05F/363	05F/366	05F/386	05F/389	05S/393	05PF/395	05RF/401	05PF/361
CHARRED REMAINS									
Cereal Grain									
Triticum aestivum/durum	Bread/Hard wheat grain	-	-	3	-	-	-	-	-
Triticum cf aestivum/durum	cf. Bread/Hard wheat grain	-	-	-	-	-	-	-	-
*Triticum cf. dicoccum (*Schubl.)	cf. Emmer wheat grain	-	-	-	-	-	-	-	-
Triticum sp.	Wheat grain	-	-	-	-	-	-	1	-
cf. Triticum sp.	cf Wheat grain	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, hulled asymmetrical grain	-	-	-	-	-	-	-	1
Hordeum vulgare L.	Barley, hulled straight grain	1	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, hulled grain	4	9	2	1	-	2	1	6
Hordeum vulgare L.	Barley grain	3	4	-	-	1	-	-	4
Hordeum vulgare L.	Barley, hulled tail grain	-	-	-	-	-	-	-	-
cf. Hordeum vulgare L.	Barley, hulled grain	-	-	-	-	-	-	-	-
Avena sp.	Oats	-	-	-	-	-	-	-	-
Sorghum bicolor (L.) Moench	Sorghum grain	-	-	-	-	-	-	-	-
cf. Sorghum bicolor (L.) Moench	Sorghum grain	-	-	-	-	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet	-	-	-	-	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet, small seeded	-	-	-	-	-	-	-	2
cf. *Pennisetum glaucum (Linn.) R. Brown*	cf. Pearl millet	1	1	2	-	-	-	-	1
cf. Pennisetum glaucum (Linn.) R. Brown	cf. Pearl millet, small seeded	-	-	-	-	-	-	-	6
Cerealia indet.	Indeterminate cereal grain	1	14	-	-	-	1	4	8
Cerealia indet	Small seeded embryo ends	-	-	-	-	-	-	-	-
Chaff									
Triticum aestivum L.	Bread type wheat, rachis	-	-	4	-	-	2	-	1
Triticum aestivum L.	Bread type wheat, basal rachis	-	-	-	-	-	-	-	-
Triticum aestivum L.	Bread type wheat, near terminal rachis	-	-	-	-	-	-	-	-
Triticum cf. *aestivum* L.	cf. Bread type wheat rachis	-	-	-	-	-	-	-	-
Triticum cf. *aestivum* L.	cf. Bread type wheat, basal rachis	-	-	-	-	-	-	-	-
Triticum durum Desf.	Hard wheat rachis	-	-	-	-	-	-	-	-

		05F/363	05F/366	05F/386	05F/389	05S/393	05PF/395	05RF/401	05PF/361
Triticum cf. *durum* Desf.	cf. Hard wheat rachis	-	-	-	2	-	-	-	-
Triticum X type	X type free-threshing wheat rachis	-	-	-	-	-	-	-	-
Triticum aestivum/durum	Bread/Hard wheat rachis	-	-	3	10	1	2	-	-
Triticum sp.	Wheat rachis	-	-	-	-	-	-	-	-
Triticum sp.	Wheat, basal rachis	-	-	1	-	-	-	-	-
cf. Triticum sp.	cf. Wheat basal rachis	-	-	-	-	-	-	-	-
Triticum sp.	Wheat rachis internode	-	-	-	-	-	-	-	-
Triticum dicoccum (Schubl.)	Emmer wheat glume base, silica	-	-	-	-	-	-	-	-
Triticum dicoccum/monococcum	Emmer/Einkorn rachis spikelet fork	-	-	-	-	-	-	-	-
Triticum dicoccum/monococcum	Emmer/Einkorn glume base, silica	-	-	-	-	-	-	-	-
Triticum sp.	Wheat glume base	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, dense eared stalked rachis	-	-	-	192	-	-	-	-
Hordeum vulgare L.	Barley, six-row rachis	-	7	5	13	3	-	7	3
Hordeum vulgare L.	Barley, dense eared rachis	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley rachis	12	15	2	9	14	4	8	13
Hordeum vulgare L.	Barley basal rachis	-	1	-	-	-	-	-	-
Hordeum vulgare L.	Barley, rachis internode	-	-	-	-	-	-	-	-
cf. *Hordeum vulgare* L.	cf. Barley rachis	-	-	-	-	-	-	-	-
Avena sp.	floret base	-	-	-	-	-	-	-	-
Sorghum bicolor (L.) Moench	Sorghum glume base	-	-	-	-	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet involucre	-	-	-	-	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet rachilla	-	1	-	-	-	-	-	-
Pennisetum glaucum (Linn.) R. Brown	Pearl millet spikelet	-	1	-	-	-	-	-	-
Cerealia indet	Rachis	-	-	3	107	7	-	-	-
Cerealia indet	Basal rachis	-	-	2	-	-	-	-	-
Cereal size	Culm nodes, large	-	-	1	9	2	-	1	-
Cereal size	Culm nodes, small	-	-	-	-	-	-	1	-
Cereal size	Basal culm (root) nodes	-	-	-	-	-	-	-	-

		05F/363	05F/366	05F/386	05F/389	05S/393	05PF/395	05RF/401	05PF/361
Chaff fragments not used in numerical analysis									
Triticum aestivum/durum	Bread/Hard wheat glume frags	-	-	1	-	-	-	-	-
Triticum sp.	Wheat, rachilla	-	-	-	-	1	-	-	-
Triticum sp.	Wheat, light chaff fragments	-	-	-	-	-	-	-	-
Triticum type	Wheat, short glume tip, silica	-	-	-	-	-	-	-	-
Triticum type	Wheat, awn/long glume tip, silica	-	-	-	-	-	-	-	-
Hordeum/Triticum sp.	Wheat/Barley awn fragment	-	-	-	-	-	-	-	3
Hordeum vulgare L.	Barley lemma frags	+	++	-	-	-	-	+++	-
Sorghum bicolor (L.) Moench	Sorghum glume frags	1	-	-	-	-	-	-	-
Cerealia indet	Rachilla	-	-	-	-	-	-	-	-
Cerealia indet	Detached embryo	-	3	-	-	-	2	-	7
Cerealia indet	Light chaff general	-	-	-	-	-	-	-	-
Cereal size	Straw lengths	-	-	-	-	-	-	-	-
Pulses									
cf. *Pisum sativum* L.	cf. Pea, hila	-	-	-	-	-	-	-	-
cf. *Vicia faba* L.	cf. Fava/Fûl bean hila/seed	-	-	-	-	-	-	-	-
cf. *Vigna unguiculata*	cf. Cow Pea hila	-	-	-	-	-	-	-	-
cf. *Lens esculenta* Moench.	Cf. Lentil	-	-	-	-	-	-	-	-
Leguminoseae	hila	-	-	-	-	-	-	-	-
Leguminoseae	seed	-	2	-	-	-	-	-	-
Anacardiaceae/Leguminosease	seed	-	-	-	-	-	-	-	-
Fruit/Vegetables									
Ficus carica L.	Fig seed	17	8	1	3	-	1	30	6
cf. Ficus carica L.	Fig seed	-	-	-	-	1	-	1	-
Vitis vinifera L.	Grape seed	5	12	1	-	2	-	5	2
Vitis vinifera L.	Grape, whole fruit/raisin	-	-	-	-	-	-	-	-
Vitis vinifera L.	Grape, immature seed	-	-	-	1	-	-	-	-
cf. *Vitis vinifera* L.	cf. Grape seed	-	-	-	-	1	-	1	-
Vitis vinifera L.	Grape stalk	2	3	1	-	-	-	-	2

		05F/363	05F/366	05F/386	05F/389	05S/393	05PF/395	05RF/401	05PF/361
Phoenix dactylifera L.	Date stone	74	32	16	1	4	2	28	18
Phoenix dactylifera L.	Date perianth	2	6	2	-	-	-	6	9
Phoenix dactylifera L.	Date rachilla	3	-	4	-	-	-	-	1
Phoenix dactylifera L.	Date embryo	20	21	3	-	8	5	33	17
Olea europea L.	Olive stone	-	-	-	-	-	1	-	1
Olea/Zizyphus sp.	Olive/Christ's-thorn stone	-	-	1	-	-	-	-	-
Citrullus sp.	Watermelon/Bitter Apple seed	-	-	-	-	-	-	-	-
Cucumis sp.	Melon/Cucumber seed	-	-	-	-	-	-	1	-
Lagenaria sp.	Gourd, seed	-	-	-	-	-	-	-	-
Cucurbitaceae	Internal seed	-	-	-	-	-	-	-	-
Cucurbitaceae	Seed fragment	-	1	-	-	-	-	-	-
cf. Cucurbitaceae	Seed	-	-	-	-	-	-	-	-
Punica granatum L.	Pomegranate seed	-	1	-	-	-	-	-	-
cf. Punica granatum	Pomegranate seed	-	-	-	-	1	-	-	-
Prunus amygdalus Batsch.	Almond	-	-	-	-	-	-	-	1
Capsicum sp.	Pepper/Chili seed	-	-	-	-	-	-	-	-
cf. *Apium graveolens* L.	Wild celery	-	1	-	1	-	-	-	-
cf. *Foeniculum vulgare* L.	Fennel								
cf. *Anethum graveolens* L.	Dill	-	-	-	-	-	-	-	-
cf. *Coriandrum sativum* L.	Coriander	-	-	-	-	-	-	-	-
cf. *Papaver somniferum* L.	Opium poppy	-	-	-	-	-	-	-	-
Indet berry		-	-	-	-	-	-	-	-
Other fruit stone frags (Prunus type)		-	4	-	-	-	-	-	1
Indet fruit	Fruit core?	-	1	-	-	-	-	-	-
Oil/Fibre Plants									
Linum usitatissimum L.	Flax capsule tips	-	-	-	-	-	1	-	-
Linum usitatissimum L.	Flax seeds	-	-	-	1	-	-	-	-
Gossypium sp.	Cotton (total seeds - mni)	-	1	-	-	-	1	2	20
cf. *Gossypium* sp.	cf. cotton (total)	-	-	-	-	-	-	-	8
Gossypium sp.	Cotton funicular apex	-	-	-	-	-	-	-	20

		05F/363	05F/366	05F/386	05F/389	05S/393	05PF/395	05RF/401	05PF/361
cf. *Gossypium* sp.	Cotton internal seed	-	-	-	-	-	-	-	21
cf. *Sesamum* sp.	cf. Sesame seed	-	-	-	-	-	-	-	-
Herbaceous Plants									
Aizoaceae									
Aizoon cf. *hispanicum* L.		-	-	-	-	-	-	-	-
Amaranthaceae									
Amaranthus cf. *augustifolius* L.		-	-	-	1	-	-	3	-
cf. *Amaranthus* sp.		-	-	-	-	-	-	-	-
Chenopodiaceae/*Amaranthus* sp.		-	-	-	5	-	-	-	-
Chenopodiaceae/Amaranthaceae/Caryophyllaceae			-	-	-	-	-	-	-
Apiaceae									
Apiaceae Jarma A		-	-	-	8	-	2	-	-
Apiaceae large seeded		-	-	-	-	-	-	-	-
Apiaceae small seeded		-	1	-	-	-	-	-	-
Apiaceae indeterminate		-	-	-	-	-	-	-	-
Asteraceae									
Calendula cf. *arvensis* L./*tripterocarpa Rupr.*			-	-	-	-	-	-	-
cf. Calendula sp.		-	-	-	-	-	-	-	-
cf. Compositae small		-	-	-	-	-	-	-	-
cf. Compositae large (>2mm)		-	-	-	-	-	-	-	-
Boraginaceae									
Heliotropium cf. *europaeum* L.		-	-	-	-	-	-	-	-
Boraginaceae A		-	-	-	-	-	-	-	-
Boraginaceae B		-	-	1	-	-	-	-	-
Boraginaceae C		-	-	-	-	-	-	-	-
Boraginaceae indet									
Brassicaceae									
Coronopus sp.		-	-	-	-	-	-	-	-
Cruciferae V, seed capsule		-	-	-	-	-	-	-	-
Cruciferae		-	-	-	-	-	-	-	-

	05F/363	05F/366	05F/386	05F/389	05S/393	05PF/395	05RF/401	05PF/361
Caryophyllaceae								
Silene cf. *gallica* L.	-	-	-	2	-	-	-	-
cf. Silene sp.	-	-	-	-	-	-	-	-
Caryophyllaceae, small seeded	-	-	-	-	-	-	-	-
Chenopodiaceae								
Chenopodium murale L.	-	-	-	-	-	-	-	-
cf. *Chenopodium murale* L.	-	-	-	-	-	-	-	-
Chenopodium sp.	-	-	-	-	-	-	-	-
Cornulaca monacantha Del. Utricles	-	-	-	-	-	-	-	1
Chenopodiaceae A	-	-	-	-	-	-	-	-
Chenopodiaceae small	1	-	-	-	-	1	1	-
Suaeda sp.	-	-	-	-	-	-	-	-
Cyperaceae								
Cladium mariscus (L.) R. Br.	-	-	-	1	-	-	-	-
cf. Cladium mariscus (L.) R. Br.	-	-	-	-	-	-	-	-
Cyperaceae A, silica	-	1	-	-	-	-	-	-
Cyperaceae	-	-	-	-	-	-	-	-
Euphorbiaceae								
Euphorbia helioscopia L.	-	-	-	1	-	-	-	-
Euphorbia peplus L.	-	1	-	-	-	-	-	-
Euphorbia sp.	-	-	-	-	-	-	-	-
cf. *Euphorbia* sp.	-	-	-	-	-	-	-	-
Fabaceae								
Alhagi sp. seeds in pods	-	-	-	-	-	-	-	-
Alhagi sp. pods	-	-	-	-	-	-	-	-
Alhagi type	1	-	-	-	-	-	1	1
Fabaceae indet	-	3	-	-	-	-	1	-
Fabaceae large/intermediate seeded, other		-	-	1	-	-	-	-
Vicia/Lathyrus sp. small seeded	-	-	-	-	-	-	-	-
Vicia/Lathyrus sp. intermediate	-	-	-	-	-	-	-	-
cf. *Onobrychis* sp. seed pod	-	-	-	-	-	-	-	-

	05F/363	05F/366	05F/386	05F/389	05S/393	05PF/395	05RF/401	05PF/361
cf. *Onobrychis* sp. seed pod	-	-	-	-	-	-	-	-
Fumariaceae								
Fumaria sp.	-	-	-	-	-	-	-	-
Liliaceae								
Asphodelus cf. *tenuifolius*	-	-	-	-	-	-	-	-
Malvaceae								
Malva sp.	-	-	-	-	-	-	-	-
Plantaginaceae								
Plantago sp.	-	-	-	-	-	-	-	-
Poaceae								
Bromus type	-	-	-	-	-	-	1	1
cf. Bromus type	-	-	-	-	-	-	-	-
Dactyloctenium aegyptium (L.) Beauc.	-	-	-	-	-	-	-	-
Digitaria B	-	-	-	-	-	-	-	-
cf. Digitaria type	-	-	-	-	-	-	-	-
*Eleusine cf. indica (*L.) Gartn.	-	-	-	-	-	-	-	-
Cynodon sp.	-	-	-	1	-	-	-	-
cf. *Cynodon* sp.	-	-	-	-	-	-	-	-
Cynodon B type	-	-	-	-	-	-	-	-
cf. *Cynodon* B type	-	-	-	-	-	-	-	-
Hordeum sp.	-	-	-	-	-	1	-	-
cf. Hordeum sp.	-	-	-	-	-	-	-	-
Lolium/Festuca type	-	-	-	-	-	-	-	-
cf. Lolium/Festuca type	-	-	-	-	-	-	-	-
Festuca pratensis gp	-	-	-	-	-	-	-	-
Paniceae indet	-	2	-	-	-	-	-	3
Paniceae indet, lemma/palea only	-	4	-	-	-	-	-	-
Paniceae indet very small	-	-	-	-	-	-	-	-
Panicum cf. *turgidum* Forsk.	-	-	-	-	-	-	-	-
Panicum cf. *repens* L.	-	-	-	-	-	-	1	-
cf. Panicum repens L.	-	-	-	-	-	-	-	-

	05F/363	05F/366	05F/386	05F/389	05S/393	05PF/395	05RF/401	05PF/361
cf. Panicum sp.	-	-	-	-	-	-	1	-
Phalaris sp.	1	5	-	1	1	-	5	2
cf. Phalaris sp.	1	1	-	1	-	-	-	-
Polypogon sp.	-	-	-	1	-	-	-	-
Setaria/Brachiaria/Echinochloa type	3	-	-	4	-	-	3	-
Setaria verticillata type	-	-	-	-	1	-	-	-
Setaria verticillata/Brachiaria ramosa type	2	-	-	-	-	-	-	-
Setaria small	-	-	-	-	-	-	-	-
Brachiaria ramosa/deflexa type		-	-	-	-	-	1	1
Brachiaria ramosa/deflexa type, palea/lemma intact		-	-	-	-	-	-	-
cf. *Brachiaria ramosa/deflexa type*	-	-	1	1	-	-	-	-
Paspalum cf. paspaloides	-	-	-	-	-	-	-	-
Poaceae 4	-	-	-	-	-	-	-	-
Poaceae N	-	-	-	-	-	-	-	-
Poaceae O	-	-	-	-	-	-	-	-
Poaceae R	-	1	-	-	1	-	-	-
Poaceae Z	-	-	-	-	-	-	-	-
Poaceae indeterminate large seeded	-	2	-	-	-	1	-	-
Poaceae, indeterminate small seeded	2	5	-	-	2	-	1	3
Poaceae (detached embryo)	-	-	-	-	-	-	-	-
Polygonaceae								
Polygonaceae indet	-	-	-	-	-	-	-	-
Portulaca								
Portulaca oleracea	-	-	-	-	-	-	-	-
cf. *Portulaca oleracea*	-	-	-	-	-	-	-	-
Primulaceae								
cf. *Anagallis arvensis*	-	-	-	2	-	2	-	-
Rubiaceae								
Galium sp.	-	-	1	1	-	-	-	-
Rutaceae								
Haplophyllum sp.	-	-	-	-	-	-	-	-

	05F/363	05F/366	05F/386	05F/389	05S/393	05PF/395	05RF/401	05PF/361
Haplophyllum sp. (seed capsule	-	-	-	-	-	-	-	-
Resedaceae								
Reseda cf. *lutea* L.	-	-	-	-	-	-	3	-
Reseda villosa/alba	-	-	-	-	-	-	-	-
Scrophulariaceae								
Linaria sp.	-	-	-	-	-	-	-	-
Solonaceae								
Solanum nigrum	-	-	-	-	-	-	-	-
cf. Solanum nigrum	-	1	-	-	-	-	-	-
Solonaceae indet	-	1	-	-	-	-	1	-
Trees/Wild fruits								
Zizyphus spina-christi (L.) Desf. fruit	-	-	-	-	-	-	-	-
Zizyphus sp.,	-	-	-	-	-	-	-	-
cf. *Zizyphus* sp.	-	-	-	-	-	-	-	-
Prosopis sp.	-	-	-	-	-	-	-	-
cf. *Prosopis* sp.	-	-	-	-	-	-	-	1
cf. *Acacia* sp.	-	-	-	-	-	-	-	-
Acacia/Prosopis type	-	-	-	-	-	-	-	-
Phoenix dactylifera L. frond fragments	-	-	-	-	-	-	-	-
Tamarix sp. leaflets	-	-	-	2	-	-	-	-
cf. Mimosaceae thorns	-	1	-	-	-	-	-	-
Indeterminate/Unidentified Seeds								
Jarma type W	-	-	-	-	-	-	-	-
Jarma TypeT	3	1	-	4	-	-	2	-
Jarma Type F	-	-	-	2	-	-	-	-
cf. Jarma Type F	-	-	-	-	-	-	-	-
Jarma Type 5	-	-	-	-	-	-	-	-
Indet small <1.5 mm	4	6	2	5	1	2	8	3
indet >1.5mm	3	4	3	-	-	-	2	1

		05F/363	05F/366	05F/386	05F/389	05S/393	05PF/395	05RF/401	05PF/361
indet unclassified		1	8	-	2	-	1	2	-
Other Query Seeds		7	1	1	-	-	-	-	-
Other (non-seed) plant items									
Type P leaves		-	-	-	-	-	-	-	-
Indeterminate leaves		-	-	-	-	-	-	-	-
Indeterminate leaf bud		-	-	-	-	-	-	16	-
Indeterminate fruit skin fragment		-	-	1	-	1	-	-	-
Indeterminate bud/flower		-	-	-	-	1	-		-
Indeterminate large thorns		-	-	-	-	-	-	-	-
Charcoal		-	-	-	-	-	-	-	-
MINERALISED PLANT REMAINS									
Ficus carica L.		-	-	-	-	-	-	1	-
Apiaceae		-	-	-	-	-	-	-	-
Apiaceae		-	-	-	-	-	-	-	-
Indet		-	-	-	-	-	-	-	-
DESICCATED PLANT REMAINS (where fewer than 30 items per sample)									
Cereal Grain									
Hordeum vulgare L.	Barley, hulled grain	1	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley grain	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, six-row grain/lemma base	-	-	-	-	-	-	-	-
Triticum aestivum L.	Bread wheat type, rachis	-	-	-	-	-	-	-	-
Triticum durum Desf.	Hard wheat rachis	-	-	-	-	-	-	-	-
Triticum aestivum/durum	Bread/Hard wheat rachis	-	-	-	-	-	-	-	-
Triticum aestivum/durum	Bread/Hard wheat basal rachis	-	-	2	-	-	-	-	-
Hordeum vulgare L.	Barley, six row rachis	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley, rachis	1	-	3	-	-	1	-	-
cf. Hordeum vulgare L.	cf. Barley rachis, desiccated	-	-	-	-	-	-	-	-

		05F/363	05F/366	05F/386	05F/389	05S/393	05PF/395	05RF/401	05PF/361
Pennisetum glaucum(Linn.) R. Brown	Pearl millet involucre	-	-	-	-	-	-	-	-
Cerealia indet	indeterminate rachis internode	-	-	2	-	-	-	-	-
Triticum aestivum/durum	Bread/Hard wheat glume frags	+	-	-	-	-	-	-	-
Triticum dicoccum/monococcum	Bread/Hard wheat glume base	-	-	-	-	-	-	-	-
Hordeum vulgare L.	Barley lemma frags	+	-	-	-	-	-	-	-
Hordeum/Triticum sp.	awn frags, desist	++	-	-	-	-	-	-	3
Cerealia indet	straw lengths	-	-	-	-	-	-	-	-
Cerealia indet	light chaff general	-	-	+	-	-	+	-	-
Vitis vinifera L.	Grape seed	-	-	-	-	-	1	-	-
Brassicaceae indet (small seeded)		-	-	-	-	-	-	-	-
cf. Carex sp.		1	-	-	-	-	-	-	-
cf. *Digitaria* sp. glumes		-	-	-	-	-	-	-	-
Phalaris sp. caryopsis and glume		3	-	-	-	-	-	-	-
Phalaris sp. glumes		-	-	-	-	-	-	-	-
Setaria/Brachiaria type		9	-	-	-	-	-	-	1
Setaria/Brachiaria type lemma/palea		-	-	-	-	-	-	-	-
Setaria/Brachiaria small type		-	-	-	-	-	-	-	-
Poaceae indeterminate, small seeded		-	-	-	-	-	2	-	-
Linaria sp.		-	-	-	-	-	-	-	-
Tamarix sp., leaflets		-	-	-	-	-	-	-	-
Jarma Type 5		-	-	-	-	-	1	-	-
Other' seed		-	-	-	-	-	-	-	-
indeterminate seed		-	-	-	-	-	-	-	-
Type P leaves, small		-	-	-	-	-	-	-	-
Indet bud/flower		-	-	-	-	1	-	-	-
Non-Plant Items									
Sheep/goat droppings charred		-	-	+	-	-	-	-	+
Sheep/goat droppings desiccated		-	-	+++	+++	-	-	-	-
Dung lumps		-	-	-	-	-	-	1	-
Mouse droppings		-	-	-	-	1	-	-	-

	05F/363	05F/366	05F/386	05F/389	05S/393	05PF/395	05RF/401	05PF/361
Fly pupae, desiccated	-	-	-	-	-	-	-	-
Fly pupae mineralised	-	-	-	-	-	-	-	-
Fly pupae charred	-	-	-	-	-	-	1	-
Large insect pupae? desiccated	-	-	-	-	-	-	-	-
Other insect fragment, charred	-	-	-	-	-	-	-	-
Bone fragments	-	-	-	-	+	-	-	-
Tooth	-	-	-	-	-	-	-	-
Fish bone	-	-	-	-	-	-	-	-
Printed/painted cloth frog., not-charred	-	-	-	-	-	-	-	-
Indet charred cloth	-	-	-	-	-	-	-	-

Appendix Four: The seed remains from Tinda B. All material charred unless otherwise stated.

	Sample	TINDA B
	Volume (litre)	2.6
Cereal Grain		
Triticum aestivum/durum	Bread/hard wheat grain	10
Triticum sp.	Wheat grain	8
Hordeum vulgare L.	Barley, six row hulled asymmetric	4
Hordeum vulgare L.	Barley, hulled, asymmetric grain	104
Hordeum vulgare L.	Barley, hulled, straight grain	295
Hordeum vulgare L.	Barley, six row hulled grain & lemma	7
Hordeum vulgare L.	Barley, hulled grain	1115
Hordeum vulgare L.	Barley, tail grain	2
cf. Secale cereale L.	cf. Rye grain - wild	1
Sorghum bicolor (L.) Moench	Sorghum grain, *caudatum* type	5
cf. *Sorghum bicolor* (L.) Moench	cf. Sorghum grain	4
Pennisetum glaucum (Linn.) R. Brown	Pearl millet	6
cf. *Pennisetum glaucum* (Linn.) R. Brown	cf. Pearl millet	3
Cerealia indet	grain	59
Cerealia indet	small seeded embryo ends	2
Cereal Chaff		
Hordeum vulgare L.	Barley, six-row rachis node	20
Hordeum vulgare L.	Barley, rachis node	10
Cereal size	culm nodes, large	2
Cerealia indet	embryo	80
Cerealia indet	embryo, sprouted	1
Fruits		
Ficus carica L.	Fig seed	6
Vitis vinifera L.	Grape seed	4
cf. *Vitis vinifera,* L.	cf. Grape seed	1
Phoenix dactylifera L.	Date fruit (whole)	6
Phoenix dactylifera L.	Date stone	42
Phoenix dactylifera L.	Date perianth	6
Phoenix dactylifera L.	Date embryo	12
Weed/Wild species		
Avena sp.		13
Hordeum sp.		2
Phalaris sp.		21
Setaria type		1
Setaria/Brachiaria/Echinochloa type		2
Brachiaria/Setaria italica type		1
Poaceae, small indet		5
Poaceae, small seeded, desiccated		1
Asteraceae, desiccated		1
Caryophyllaceae		1
Jarma Type 5, desiccated		1
Indeterminate		1
sheep/goat droppings, charred		+++

Appendix Five: Archaeobotanical data from al-Basra, Morocco

Year	Basra 94	Basra 94	Basra 94	Basra 94	Basra 94	Basra 98	Basra 98
sample no./loci	F8/4-0	F8/5-1	F8/7-3	F8/10-3	F8/15-7	F9/6-7	F9/7-11
Description					Dark soil	soil in top of oven	
Volume	4	4	3	4	2	1.25	3
Cereals							
Triticum dicoccum grain							
Triticum cf. *dicoccum* grain		1					
Triticum monococcum grain		1					
Triticum cf. *monococcum* grain		1					
Triticum dicoccum/monococcum grain		3					
Triticum aestivum/durum grain							
Triticum cf. aestivum/durum grain							
Triticum sp. grain		8		1			
Hordeum vulgare grain		1					
Hordeum vulgare grain	1	3	3				
Hordeum vulgare grain		2					
Panicum miliaceum grain						1	
cf. *Panicum miliaceum* grain				1			
Cerealia indet, grain		16	3	6		2	
Fruit/Pulses							
Vicia/Pisum/Lens sp.		1			1		1
Ficus carica, seed		3		1		2	1
Vitis vinifera, seed		1					
Weed/Wild Taxa							
Chenopodium album							
Chenopodium murale							
Labiatae							
Boraginaceae	6						
cf. *Torillis japonica*				1			
Vicia/Lathyrus sp.							
Rumex sp.		3					
Compositae							
Phalaris canariensis		4	1			2	1
Phalaris sp.							
cf. *Lolium* sp.		1					
Poaceae		1	1				1
Cyperaceae							
Indet		2					
Indet, mineralised							
Query a							
Query b							
Charcoal					+		

Appendix Five cont.: Archaeobotanical data from al-Basra, Morocco

Year	Basra 94	Basra 99	Basra 99	Basra 99	Basra 99	Basra 99
sample no./loci	G4 N0W15	G4/N0W 10	G4/N0W 15	G4/N5W 20	G4/S23 W6	G4/S 23W6
Description	Silo sample Feature 2	ll 4.4	soil from pot ll 3.4	inside pot ll 4.0	ll 4.4	4.8
Volume	4	2.5	1.75	2	1	1
Cereals						
Triticum dicoccum grain						
Triticum cf. *dicoccum* grain		1				
Triticum monococcum grain						
Triticum cf. *monococcum* grain						
Triticum dicoccum/monococcum grain			2			
Triticum aestivum/durum grain						
Triticum cf. aestivum/durum grain			1			
Triticum sp. grain						
Hordeum vulgare grain	1					
Hordeum vulgare grain						
Hordeum vulgare grain		1	1			
Panicum miliaceum grain	1					
cf. *Panicum miliaceum* grain		2				
Cerealia indet, grain		1	4			
Fruit/Pulses						
Vicia/Pisum/Lens sp.			1		1	
Ficus carica, seed	5	2				
Vitis vinifera, seed	3			1		
Weed/Wild Taxa						
Chenopodium album	1					
Chenopodium murale						
Labiatae						
Boraginaceae						
cf. *Torillis japonica*						
Vicia/Lathyrus sp.			1			
Rumex sp.						
Compositae						
Phalaris canariensis						
Phalaris sp.			1			
cf. *Lolium* sp.						
Poaceae			1			
Cyperaceae	50					
Indet	4	2	6			
Indet, mineralised						1
Query a	2					
Query b			2			
Charcoal		+		+	+	+

Appendix Five cont.: Archaeobotanical data from al-Basra, (all Basra 99, loci G4/NoW20

Year	Basra 99							
sample no./loci	G4/N0W20							
Description	ll 8.9	inside pot ll 8.8	ll 5.5	ashy spread 5.4	ll 3.2	ll 8.8	8-7	plaster floor 6.4
Volume	2.5	2.05	2.5	2.5	2.5	2	2.5	2.5
Cereals								
Triticum dicoccum grain								
Triticum cf. *dicoccum* grain			1	3	1			
Triticum monococcum grain			5					
Triticum cf. *monococcum* grain			2					
Triticum dicoccum/monococcum grain				1				
Triticum aestivum/durum grain								
Triticum cf. aestivum/durum grain								
Triticum sp. grain	1		8		1			
Hordeum vulgare grain			1					1
Hordeum vulgare grain			3	3				2
Hordeum vulgare grain								1
Panicum miliaceum grain				4				7
cf. *Panicum miliaceum* grain					2			
Cerealia indet, grain	1	1	15	3		2		2
Fruit/Pulses								
Vicia/Pisum/Lens sp.	1		4			1		
Ficus carica, seed								2
Vitis vinifera, seed							1	
Weed/Wild Taxa								
Chenopodium album					2			
Chenopodium murale			1	2				
Labiatae			1					
Boraginaceae								
cf. *Torillis japonica*								
Vicia/Lathyrus sp.			1					
Rumex sp.			1					
Compositae					1			
Phalaris canariensis			7	2	2		1	
Phalaris sp.								
cf. *Lolium* sp.								
Poaceae			4					2
Cyperaceae								
Indet		2	8	5	5		+	2
Indet, mineralised								
Query a								
Query b								
Charcoal	+	+						

Appendix Six: Charred Plant Remains from Lepcis Magna 1996

Sample	21	28	29	31	32
Context	211	223	208	244	263
Hordeum vulgare, hulled grain	-	3	-	-	1
Hordeum vulgare, hulled twisted grain	-	-	-	-	1
Hordeum vulgare grain	-	3	-	-	-
Triticum sp. grain	-	1	-	-	-
Cerealia grain	-	4	-	2	-
cf. *Lens esculenta*	-	1	-	-	-
Vicia cf. *ervilia*	-	1	-	-	-
Pisum sativum, hilum	-	1	-	-	-
Vicieae large	-	1	-	-	-
Ficus carica	1	-	-	1	-
Olea europea	-	-	-	130	-
cf. *Olea europea* inner seed	-	-	-	9	-
Olea/Prunus type stone fragment	-	-	1	-	-
Cruciferae	-	1	-	-	-
Malva sp.	-	-	-	-	1
Fabaceae small	-	-	-	1	-
Medicago/Trifolium type	-	1	-	-	-
Emex spinosus	1	-	-	-	-
Euphorbia sp.	1	-	-	-	-
Euphorbia sp. (silica)	-	-	-	1	-
Bromus sterillis type	-	1	-	-	-
Poaceae small	-	1	-	-	-
ignota	1	2	-	-	1

Appendix Seven: Summary of charred plant remains from Volubilis (Fuller, Pelling and De Varailles, *forth.*)

Species	Period	Total	Ubiquity (%)
Triticum aestivum/durum grain	Early Islamic	114	65
Triticum cf. *aestivum/durum* grain	Early Islamic	2	5
Triticum cf. *dicoccum* grain	Early Islamic	3	10
Triticum cf. *dicoccum/monococcum* grain	Early Islamic	3	15
Triticum sp. grain	Early Islamic	204	60
Triticum/Secale cereale grain	Early Islamic	1	5
Hordeum vulgare, hulled twisted grain	Early Islamic	18	40
Hordeum vulgare, hulled	Early Islamic	115	70
Hordeum vulgare	Early Islamic	143	60
cf. *Secale cereale*	Early Islamic	1	5
Avena sp.	Early Islamic	1	5
cf. *Panicum miliaceum*	Early Islamic	1	5
Panicum miliaceum	Early Islamic	3	5
Oryza sp.	Early Islamic	1	5
Cerealia	Early Islamic	528	95
Triticum aestivum/durum rachis	Early Islamic	25	25
Triticum cf. *durum* rachis	Early Islamic	2	10
Triticum dicoccum, glume base	Early Islamic	1	5
Triticum dicoccum/monococcum, glume base	Early Islamic	3	15
Triticum sp., rachis	Early Islamic	1	5
Hordeum vulgare, six-row rachis	Early Islamic	1	5
Hordeum vulgare, rachis	Early Islamic	5	10
Cerealia, embryo	Early Islamic	9	20
Poaceae, culm node	Early Islamic	3	5
Fabaceae large	Early Islamic	7	25
Lens esculenta	Early Islamic	1	5
Vicia faba	Early Islamic	3	10
cf. *Vicia faba*	Early Islamic	2	5
Gossypium sp.	Early Islamic	157	25
Gossypium sp.	Early Islamic	24	15
cf. *Gossypium* sp., funicular apex	Early Islamic	1	5
Linum usitatissimum	Early Islamic	18	30
cf. *Linum* sp., seed	Early Islamic	12	5
Olea europea, stone	Early Islamic	1	5
Olea/Zizyphus sp., stone	Early Islamic	4	20
Fruit - *Olea* type stone	Early Islamic	1	5
Vitis vinifera	Early Islamic	24	55
Vitis vinifera, stalk	Early Islamic	1	5
Ficus carica	Early Islamic	23	35
Ficus carica, mineralised	Early Islamic	1	5
Ficus carica, silica	Early Islamic	2	10
Vol - FRUIT A	Early Islamic	3	10
Fruit?	Early Islamic	1	5
Indet nut/fruit frag.	Early Islamic	7	35
Anagallis arvensis type	Early Islamic	2	10
Carex sp.	Early Islamic	1	5
Caryophyllaceae	Early Islamic	1	5
Chenopodiaceae	Early Islamic	2	10
Chenopodium album	Early Islamic	60	35

Chenopodium murale	Early Islamic	4	15
Chenopodium cf. *murale*	Early Islamic	1	5
Chenopodium sp.	Early Islamic	5	15
Chrysanthemum sp.	Early Islamic	1	5
Cyperaceae	Early Islamic	16	5
Emex spinosus	Early Islamic	5	5
Euphorbia peplus	Early Islamic	1	5
Euphorbia spp.	Early Islamic	2	5
Fumaria sp.	Early Islamic	1	5
Galium sp.	Early Islamic	10	20
Poaceae, large seeded	Early Islamic	5	15
Poaceae small seeded	Early Islamic	27	30
Hordeum sp. wild type	Early Islamic	3	10
Hyoscyamus niger	Early Islamic	3	15
Labiatae, mineralised	Early Islamic	2	10
Lithospermum sp.	Early Islamic	1443	15
Lolium type	Early Islamic	92	60
Malva sp.	Early Islamic	29	65
Medicago/Trifolium sp.	Early Islamic	38	50
Mimosaceae type, thorn	Early Islamic	1	5
Phalaris canariensis	Early Islamic	882	40
cf. *Phalaris canariensis*	Early Islamic	38	15
cf. *Phalaris minor*	Early Islamic	1	5
Phalaris sp.	Early Islamic	28	20
Plantago sp.	Early Islamic	1	5
Polygonum lapathifolium/persicaria	Early Islamic	1	5
Polygonaceae	Early Islamic	7	20
Portulaca oleracea	Early Islamic	2	5
Ranunculus sp.	Early Islamic	1	5
Raphanus raphanistrum capsule frags.	Early Islamic	1	5
Rubiaceae	Early Islamic	10	15
Apiaceae/Rubiaceae	Early Islamic	10	20
Apiaceae/Rubiaceae mineralised	Early Islamic	3	5
Rumex sp.	Early Islamic	29	35
Setaria/Panicum type	Early Islamic	1	5
Silene sp.	Early Islamic	3	15
Vicia/Lathyrus sp.	Early Islamic	6	10
Vicia/Lathyrus/Lens sp.	Early Islamic	1	5
Urtica urens	Early Islamic	1	5
ignota	Early Islamic	209	65
ignota, mineralised	Early Islamic	5	10
ignota	Early Islamic	1	5
Other	Early Islamic	8	20

Appendix Eight: The charred plant remains from Lambeisis 1990 excavations

	Context	560	655	508	481	526
Triticum aestivum	Bread type wheat rachis	-	-	1	-	-
Triticum cf. *durum*	cf. Hard wheat rachis	-	-	1	-	-
Hordeum vulgare	Barley, hulled asymmetric grain	-	-	-	-	1
Hordeum vulgare	Barley, hulled grain	-	2	-	1	-
Cerealia indet	Cereal grain	-	1	2	-	-
Cereal size	cereal sized culm node	-	-	1	-	-
Lens esculenta	Lentil	8	-	-	-	-
cf. *Vitis vinifera*	Grape seed	-	-	1	-	-

Appendix Nine: Coding and habitat/season information used in the correspondence analysis in chapter 7 (only weeds used in the final analysis given).

Code	Taxa	Habitat code	Season code
Aizsp.	*Aizoon* sp.	1/2	?
Anatyp	*Anagallis* type	4/7	?
Anegra	*Anethum graveolens*	1/7	WA
Apigra	*Apium graveolens*	WA	WA
Aspsp.	*Asphodelus* sp.	1/2	Aw
Avesp.	*Avena* sp.	1/2	Ww
Bra/Set	*Brachiaria/Setaria* sp.	1/4	Sw
Bra/Sin	*Brassica/Sinapis* sp.	7	Aw
Braram/def	*Brachiaria ramosa/deflexa*	1/4	Sw
Brotyp	*Bromus* type	1/4	Aw
Carsp.	*Carex* sp.	1/6	?
Cartin	*Carthamus tinctorius*	WA	WA
Chealb	*Chenopodium album*	1/2	Aw
Chemur	*Chenopodium murale*	1/2	Aw
Chesp.	*Chenopodium* sp.	1/2	Aw
Corsat	*Coriandrum sativum*	WA	WA
Cypsp.	*Cyperus* sp.	6	Aw
Euppep	*Euphorbia helioscopia*	1	Ww
Eupsp.	*Euphorbia* sp.	7	?
Fumsp.	*Fumaria* sp.	1	Ww
Galsp.	*Galium* sp.	7	?
Gossp.	*Gossypium* sp.	SA	SA
Horsp.	*Hordeum* sp.	1/7	Ww
Horvul	*Hordeum vulgare*	WA	WA
Horwild	*Hordeum* sp. wild type	7	Ww
Lathsp.	*Lathyrus* sp.	1/2	Ww
Lencul	*Lens culinaris (=esculenta)*	WA	WA
Linusi	*Linum usitatissimum*	WA	WA
Loltem	*Lolium temulentum*	1	Ww
Loltyp	*Lolium* type	1	Ww
Malsp.	*Malva* sp.	1/2	?
Med/Mel	*Medicago/Meliotus* sp.	7	Aw
Paniceae	Paniceae	1/4	Sw
Pansp.	*Panicum* sp.	1/4	?
Pengla	*Pennisetum glaucum*	SA	SA
Phasp.	*Phalaris* sp.	1/2	Ww
Pisumsp.	*Pisum* sp.	WA	WA
Polsp.	*Polygonum* sp.	7	?
Porole	*Portulaca oleracea*	1/6	Sw
Ressp.	*Reseda* sp.	4	?
Riccom	*Ricinis communis*	WA	WA
Rumsp.	*Rumex* sp.	7	?
Setsp.	*Setaria* sp.	7	?
Silsp.	*Silene* sp.	½	Aw
Solsp	*Solanum* sp.	1/2	Aw
Sorbic	*Sorghum bicolor*	SA	SA
Suasp.	*Suaeda* sp.	4	?
Triaes/dur	*Triticum aestivum/durum*	WA	WA
Tridic/mon	*Triticum dicoccum/monococcum*	WA	WA

Triticum	*Triticum* sp.	WA	WA
Vic/Lath	*Vicia/Lathyrus* sp.	1/2	Ww
Vicerv	*Vicia ervilia*	WA	WA
Vicfab	*Vicia faba*	WA	WA
Vicsp.	*Vicia* sp.	½	Ww

Key for habitat/season codes

1 fields
2 taxa of waste ground
4 steppe/dessert
6 wet places including irrigation channels
7 unknown/catholic

WA winter arable crop
SA summer arable crop
WW winter weed
SW summer weed